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SOME ASPECTS OF SECONDARY SCIENCE EDUCATION*

D. S. KOTHARI

The role of science and technology in the rapid progress of a country like ours is bound to be of the utmost significance. People in many lands, including our own, have contributed to the advance of science and its sustained progress. A fundamental example that immediately comes to one's mind is that all elementary particles in nature—be these electrons, protons or what not—are either Fermions or Bosons, these being named after the great Enrico Fermi and our great physicist Professor Satyen Bose of the University of Calcutta, who first studied the relevant quantum statistics about 1924. Science is a collective activity of mankind, and it is this which has led to its extraordinarily rapid, almost exponential growth. Scientific knowledge is doubling itself in some 15 years, and this means that a "normal individual" must necessarily soon get out-of-date—in fact, far too much out-of-date—in relation to his awareness of the fast changing world around him. We cannot help this; but what we must ensure is that the new generation studying in the schools, colleges and the universities is taught what is reasonably modern and not fed on what is obsolete. So rapid is the pace of progress in scientific research these days that, as has been aptly said, "What is in print is *ipso-facto* out of date". There is no time to pause to consider why in a relatively short period of time progress in science has been so much, and so rapid, as compared to other fields of human endeavour. The basic reason, of course, is that in the field of science—within the confines of the laboratory—the pursuit of excellence, objectivity and integrity, and rejection of narrow selfishness are much more easy to cultivate than in other fields, e.g., politics. Science encourages *co-operation* rather than *competition*, and its roots lie deep in man's highest aspirations and in his noblest motivations, more spiritual than material.

Everyone knows that nuclear physics, space exploration and micro - or molecular biology are the most exciting fields of current scientific research. It has been said, for example, that man has learnt during the last ten years more about the essential life processes, e.g., nature of genes, protein synthesis and so on, than during all the preceding centuries. As Weinberg (*Science*, 21 July 1961) has recently remarked: "The probability of our synthesising living material from non-living before the end of the century is of the same order as the probability of our making a successful manned round trip to the planets". In both cases the probabilities are high, provided the world is not plunged into a nuclear war. What our own contribution is likely to be in the things to come, great and small,—and even our realization of the welfare state—would depend primarily on the emphasis we place on education and pursuit of knowledge. As J. B. Conant (President Emeritus of Harvard University, U.S.A.) has recently observed: "The record shows it is a most difficult undertaking for a people to make a democratic government an effective, stable government. History has shown how readily a democracy may be destroyed by radicals to the right or to the left. Therefore, I say, the prime responsibility of educators in a democratic nation is to do what they can to ensure the preservation of that form of government which protects the maximum of political, social and cultural freedom."

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* Address by Dr D. S. Kothari, Chairman, University Grants Commission at the sixth annual conference of the All India Science Teachers' Association, held at Udaipur on December 26, 1961.

The prosperity and strength of a country these days are directly dependent on the level of scientific and technical knowledge cultivated in the country and on its capacity to make use of that knowledge to serve practical ends. Let us note in passing that in the contemporary industrial and political climate, it is not too difficult for a newly developing country to build (with the assistance of industrially advanced countries) new fertilizer factories, steel plants, and so on; and these take only a couple of years or so to install. But to manage and run the plants efficiently and to maintain them properly, it requires a large number of competent technical men. It takes several years to train such men, and it is no easy task by any means. It demands a massive and reasonably sound educational system in the country. A very important part of the system, and specially so in relation to industrial development, is that of secondary education. As Sir Charles G. Robertson has observed in his inimitable book (*The British Universities*, p. 281, Benn's Sixpenny Library, London, 1930): "...if the nineteenth century was to prove up to the hilt one salutary truth it was that without an efficient and progressive system of secondary education, efficient and progressive universities were impossible."

At a recent conference, the Duke of Edinburgh (*Nature*, August 19, 1961) gave four basic reasons why every country should organize its technical training as efficiently as possible: "*Firstly*, the standard of intelligence, competence and workmanship in industry, commerce and agriculture controls absolutely the ability of any country to hold its own in the highly competitive business of international trade. *Secondly*, even in the least-developed countries, there is growing mechanization in all the public services, such as transport, communications, water, power and light. In the more developed countries, mechanization has gone much farther. As a result, there is a growing need for technically competent persons capable of maintaining this increasingly complicated mechanical complex. *Thirdly*, technical training is essential if individuals are to make the best use of their aptitudes; and *fourthly* is the need for teachers, especially in technical subjects. . . . It should be obvious that the less developed countries are less developed because the standard of technical knowledge is not very high, and the United Kingdom has the duty of providing more teachers not only for her own expansion but also for the developing countries of the Commonwealth."

THE PROBLEM OF NUMBERS

In this Conference we are concerned with the place of science in secondary education. Let us note the order of the numbers that are involved here. The total number of students at school these days is some 44 million - it was some 18 million in 1947. At the end of the Third Plan the number is likely to be 65 million. The number of school-going children beyond the 8th class (that is in the 9th, 10th and 11th classes) is at present 3 million. This is some 12 per cent of the population in the corresponding age group. The number is expected to rise from 3 million to somewhat more than 5 million by the end of the Third Plan. In the U.K. the number of students in school in the age group 11 to 14 is about 2.23 million and in the age group 15 to 18 it is about one-third of a million. These numbers are considerably less than what we have in India. About 60 years ago in the U.K., the percentage of all boys and girls aged 14 or 15 who were in school was only 4 per cent. In the case of the age of 16 to 17, the number was only 1 per cent. It was not until 1918 that full-time education up to the age of 14 was made compulsory.

The total expenditure on education in India is at present of the order of Rs. 3,500 million per year. It was some Rs. 580 million in 1947. (In the U.S.A., in 1955, the total expenditure on education was $11 billion, or 3.6 per cent of the gross national product, distributed as follows: Public elementary and secondary = $9.4 billion, Private elementary and secondary = $1.2 billion, Public higher education—$1.5 billion, Private higher education = 1.9 billion; the latest for 1961 is some $26 billion.)[1]

SPECIALIZATION AT SCHOOL

At the stage of school education, specialization should be avoided as far as possible. The bulk of the course should be common to all students. One of the serious defects of the present higher secondary school system in our country is that it requires a student hardly 13 years of age, to decide about the subjects he would later take up at the university. In other words, the choice of occupation has to be made when a student has hardly the ability or is in a position to make the choice. It is now widely recognised that school education should be wide in character and avoid specialization. For example, the Science Masters' Association in the United Kingdom has recently issued a Policy Statement[2] which says: "All pupils should follow a balanced course of science subjects up to the end of their fifth form year. ..There should in fact be no division into science specialists and arts specialists until beyond this level, so that specialization in arts or sciences, or even a combination of the two, may be available to all pupils of the necessary ability when they enter the sixth form. ..Science should be studied by all pupils in the sixth form". Again, in the U.S.S.R., all students, and not just those who would later take up science, do a considerable amount of mathematics and physics. Every student in his final year at school (the school course is from the age of 7 to 18) covers such topics as atomic structure, artificial radioactivity, energy released in nuclear reactions, cosmic rays, nuclear power stations, use of radioactive isotopes in agriculture and industry, and so on[3] Education should train young people for life and as such they all must do a good deal of physics, and "work, work and work". It is very important that some special attention (in 'course work' and other respects) is given to the talented students, the top 3 per cent or so of the student population. They consitute the nation's most precious asset. This and other basic problems of high school education are discussed in J.B. Conant's[4] 'history-making' study of the American high school education a 'must reading' for every one interested in school education.

SCHOOL CURRICULUM

Another matter which should receive earnest consideration is that of the modernization of the school curriculum.[5] Let us take the example of physics. In the teaching of physics (and for that matter any science subject) great stress has to be laid on clarity of presentation, inclusion of adequate, *but not over-much,* mathematics; and encouraging the students to think and apply the fundamental principles to concrete situations. It means that great effort and care are necessary in the selection of competent teachers and this is particularly so when dealing with those parts of the subject where emphasis is on concepts and ideas as distinct from information, data and facts Bad teaching will generate confusion, and in worse cases may even distort science into superstition. The basic point is that the content of a syllabus must be directly related to the competency of the available teachers. A first-class syllabus, but without first-class textbooks and other essential teaching aids, would in the hands of third-rate teachers result only in chaos and confusion. In such circumstances a less ambitious, even mediocre syllabus, would yield better results.

The new science syllabus should emphasise science as a major human activity —as a means to discovering truth about nature. "As a human quest for truth, it (science) is much concerned with basic values and is indeed an active humanity, and it follows that schools have the duty of presenting science as part of our cultural and humanistic heritage, to be taught in harmony with, not in opposition to, the various arts subjects which alone have hitherto been called humanities.

TEXTBOOKS

The question of textbooks is the most important and urgent one for our country. Energetic action, on State and national basis, is required to progress the preparation of high-quality school-textbooks.

In this task we can take real help from some of the excellent textbooks that have recently been prepared (particularly in the United States and the U.S.S.R.), for example, the textbook on physics for secondary schools prepared by the Physical Science Study Committee (USA) under a grant from the National Science

Foundation and also the Ford Foundation. The Committee consists of a group of university and secondary school physics teachers including some names internationally known for their contribution to research in physics. The school textbook apart from the fundamentals of classical physics also describes in simple language elementary ideas about atomic energy, wave mechanics and so on. The book opens with the statement: "Physics is the fundamental science of the Natural World. It tells us what we know about that world, how men and women found out what we know, and how they are finding out more today", and it concludes with the paragraph, "We have therefore come to the threshold of many new developments. In the years since 1925 (when wave mechanics was formally stated) wave mechanics has given us a great deal of understanding of the physics that was previously mysterious. There is much to be studied in these new fields, some of it already fairly well understood and a great deal of it the subject of the present work. This book is barely an introduction. A life can be well spent in a study of the physical world."

A new textbook on high school chemistry was prepared (under the auspices of the great chemist G.T. Seaborg, now Chairman of the U S Atomic Energy Commission) by nine college and university professors and nine high school teachers in a period of six weeks. "The high school teachers kept the college and university professors down to earth and the latter helped to raise the sights of the professional teachers. It was a mutually beneficial experience and this has been true of similar task forces in the other scientific disciplines.' Of particular importance are the following observations of Seaborg at the annual banquet of the National Science Teacher's Association, March 27, 1961."

"I turn now to a discussion of what seem to me to be four definite trends towards improvement of science teaching in the secondary schools. They are: One improving the course content; two new emphasis on laboratory work, three - scaling up teacher training and standards; four - breaking down of barriers that for too long have cast the professional scientist and the professional teacher in the role of antagonists instead of collaborators."

Also, he pointed out: "The high school teacher should hold a B.Sc. or a B.A. with a major in the field that he is teaching, in addition to the required accreditation courses. Only a small fraction of our teachers are so prepared.

The National Science Foundation reports that of the 22,000 mathematics and science teachers currently entering into service annually, only 6,000 are fully accredited. The other 16,000, recruited because of the desperate shortage of teachers, all too often have only partial or uncertain competence.

One big problem is low teacher salaries. Pay increases are coming through but not fast enough. I know that your organization and the National Education

Association are hard at work on this problem. Anyone thinking about improving science teaching in high schools must face the necessity for getting substantially increased funds for teacher salaries. These funds will come from local and state agencies and from substantially increased indirect aid to schools from Federal funds. One of the purposes of the Education Bill now pending in the Congress is to step up the indirect Federal assistance."

Good textbooks are absolutely basic to the entire educational process. Further, really good teachers are a very scarce commodity and therefore things (e.g., textbooks, demonstration apparatus and other teaching aids) should be so organised as would make it possible for a teacher of average quality to impart proper education in content and quality. If science education is to be carried out on a massive scale, there is no other alternative. (This is borne out by what has been done in the U.S.S.R. during recent years)

PARTICIPATION OF SCHOOL TEACHERS AND STUDENTS IN COLLEGE-UNIVERSITY WORK

A selected number of the specially meritorious teachers should be given some opportunity to participate in advanced study and research at university centres, National Laboratories and other similar institutions. This can be arranged during summer vacations. Reasonably liberal grants should be provided for the purpose. Contact with research, with 'living science' as it were, could generate in the teacher a new enthusiasm and interest in the subject, and this in turn would pass on to his students. The research participation should be organised carefully at a few selected centres to begin with; and for (say) a few hundred teachers every year. Summer Schools for what are usually termed 'refresher courses' should also be organised for school teachers. These programmes would help to bridge to some extent the present wide gap between school and university teachers, and this would benefit both.

Complementary to the above scheme, provision should be made for a selected number of top students in schools to spend their summer vacation at first-rate university centres, National Laboratories and professional colleges (specially selected for the purpose). This would expose some of our gifted students during their most impressionable years to the inspiring and exhilarating influence of outstanding men in the academic profession. It would considerably accelerate their scholarly development. We should do the same for a selected number of college undergraduates.

The schemes described above, apart from their value in raising the standard and quality of science education, would also help, may be to a small extent, the process of 'emotional integration' and in generating a corporate academic atmosphere in the country.

LABORATORY EQUIPMENT AND WORKSHOPS

For the expansion of science education in our country, it is very important to develop simple apparatus and equipment of good instructional value. This is an important and urgent task. Sections, or even divisions, for this purpose could with profit be established in some of the National Laboratories and university departments.

Every high school should be provided with a reasonably good workshop, say carpentry tools, simple mechanic's kit, and possibly a manual lathe. Teachers and students should be encouraged to build simple apparatus in the school workshop. One learns a lot of good science by using a simple and inexpensive apparatus to the limit of its capability and accuracy. On the other hand, one hardly learns little of real value by using a first-rate instrument in a third-rate way, as unfortunately is very often the case in our laboratories.

In the case of school buildings, it should be possible to improve effectively their fundamental utility, and at the same time cut down costs. Much thought has been given to this subject in recent years. For example, see: Ministry of Education (UK)., *The Story of Postwar School building*, Pamphlet No 33 (HMISO 1957).

TEACHER SHORTAGE

For the implementation of the programme of secondary education during the Third Plan more than 60,000 additional teachers would be required. The shortage of teachers in India is a serious problem. In fact, this has now become an acute world problem, and it is much more accentuated in India. If we are to meet the problem of shortage of teachers, an approach, unconventional in many ways, would be required. For example, it may be desirable to introduce education as a part of the first degree course.

To meet the problem of serious shortage of mathematics teachers U.K. (University College, London) has recently launched a scheme of evening classes designed for teachers working in schools. As the well-known Crowther Report (1959) says: "It is necessary to do more than is being done to attract men and women of the highest intellectual calibre into teaching."

The teaching profession should be made really an attractive one. In this connection reasonable salaries are important, but by no means everything. Opportunities of professional advancement, possibility of migration to a college or university, recognition by the society of the value and importance of the teaching profession, and many such things would go a long way in attracting to the profession a modest proportion of men and women of high intellectual abilities and character. This is an essential requirement for realising as we must the kind of society we all have in view.

Education provides a good illustration of the 'feed-back' process. If things are so organised that every year an appreciable number of our best young men join as teachers in our schools and colleges, we shall have a continually escalating improvement in education. On the contrary, if what we plough back into our schools and colleges are young men with less than average ability, then standards would rapidly (exponentially) go down as years roll by. The key to a continuous improvement of standards is to feed back into the teaching profession every year a reasonable proportion of the best young men turned out from the universities.

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DISCOVERY OF VITAMINS

P. MAHESHWARI

Department of Botany, Delhi University

There is an ancient eastern saying: "Better to walk than to run; better to sit than to walk; better to sleep than to sit; and better to die than to wake." This is certainly applicable to the many who are undernourished, for the fire of life burns low in their bodies and they are apt to take things as they are instead of making an all out effort to get over their troubles. Not every case of undernourishment and ill health is, however, due to poverty; surprisingly enough, some are associated with wealth and abundance. It is the purpose of this article to consider one such aspect.

As is wellknown, our foods contain proteins, carbohydrates, fats, mineral salts and water. Those that are derived from plants also have some fibrous material. This "roughage" has little nourishment in it, but is valuable for enabling the intestines to push the food forward.

Besides the above, foods also contain minute quantities of other substances. Although not concerned directly in making protoplasm, or in oxidation, the absence of these things gives rise to what are known as deficiency diseases. To this category belong the vitamins. Although every school boy or girl talks of vitamins these days, no one had any clear knowledge of them until about sixty years ago.

Scurvy, a disease caused by vitamin deficiency, was mentioned in the writings of Hippocrates (430-370 B.C.), the father of western medicine, as a scourge of armies and exploring seamen. It was recognised by a weakening of the walls of the capillaries so that blood escaped easily through them. Large black bruises were formed, blood came out of the nose, the gums became soft and swollen and frequently the teeth fell out. Sometimes the feet became swollen so as to produce a dropsical condition and the breath became offensive. Barber-surgeons were employed to cut away the dead flesh from the gums to enable a sufferer to masticate his food. After considerable misery, many of the victims died.

Scurvy is repeatedly mentioned in the records of the Crusades during the thirteenth century. It appeared very frequently in places where people lived on a restricted diet as in encampments of soldiers in besieged towns. During the 16th, 17th, and 18th centuries explorers going on long voyages suffered so badly from its ravages that it became known as the "calamity of sailors". Two-thirds of Vasco da Gama's crew died from it off the cost of Africa; it had a deadly effect on

Magellan's men, and it had been taken quite seriously by Francis Drake. The heavy mortalities on Columbus'.voyages were also due mostly to scurvy.

No one knew the cause of the disease. Some blamed sea air, while others attributed it to the consumption of salted meat.

In the winter of 1536, Jacques Cartier, the French explorer who discovered the St. Lawrence River, made his second voyage to Newfoundland and spent a winter in an American Indian Village near the present site of Montreal. Out of a crew of 110, 26 died of scurvy, and others would probably have met a similar fate if they had not followed the advice of the natives and drunk a tea made of spruce needles. The results were "miraculous". If all the physicians of Montpellier and Louvain "had been there", said Cartier, "with all the drugs of Alexandria they would not have done so much good in one year as that tree did in six days."

The voyages of James Cook in the 18th century are especially noteworthy in this connection. On the first voyage Cook lost so many men by scurvy that he swore that "if his own life was spared he would devote all his intelligence and energy to combating scurvy." On the second voyage after spending several months at sea in the region of the Antartic Circle he landed in New Zealand. Here he gathered the buds and needles of a pine, brewed them with molasses and malt, and made a decoction which benefited his men immensely. Several years before Cook's first voyage, a Scottish naval physician, James Lind (1716-94) made an interesting experiment on board the *Salisbury*. He divided twelve men suffering from scurvy into six groups of two each. Two men were given cider each day, two vinegar, two oil of vitriol, two half a pint of sea-water, two a patent lactuary, and the last two a couple of oranges and one lemon. The fortunate ones who received oranges and lemons were cured in six days, the cider drinkers showed a slow improvement, while the other pairs remained almost as before.

Lind's own account of his test is as follows. "On the 20th May, 1747, I took twelve patients in the scurvy, on board the Salibury at sea. Their cases were as similar as I could have them...... .Two of these were ordered each a quart of cyder a-day. Two others took twenty-five drops of elixir vitriol three times a-day.. Two others took two spoonfuls of vinegar three times a-day upon an empty stomach ... Two of the worst.... were put under a course of sea-water ...Two others had each two oranges and one lemon given them every day... The two remaining patients, took the bigness of a nutmeg three times a-day, of an electuary recommended by an hospital surgeon ...

"The consequence was, that the most sudden and visible good effects were perceived from the use of the oranges and lemons; one of those who had taken them, being at the end of six days fit for duty......The other was the best recovered of any in his condition; and being now deemed pretty well, was appointed nurse to the rest of the sick. ."

At another place, he wrote: "Some persons cannot be brought to believe that a disease so fatal and dreadful can be prevented or cured by such easy means. They would have more faith in some elaborate composition dignified by the title of an antiscorbutic golden elixir or the like . .Facts are sufficient to convince the unprejudiced. It is no easy matter to root out old prejudices or overturn opinions which have acquired an establishment by time, custom and great authorities."

In 1753 Lind wrote a book in which he mentioned the case of a sailor who had gone to Greenland in 1834. He was so sick with scurvy that his companions marooned him to die. He had nearly lost the use of his limbs and could only crawl over the ground. Even in this hopeless condition, the cravings of hunger overcame the despairs of his disease and he grazed like a beast upon the young shoots of green grass. In a short time he recovered and returned to his companions.

Since fresh vegetables could not be carried long distances in those days owing to the lack of refrigeration facilities, in 1795 the British Admiralty decided to adopt lemon juice as the principle antiscorbutic. After this the incidence of scurvy showed a starting decline in the Navy, although no one knew the exact reason for this. Even so, owing to lack of fresh fruits thousands of Indian soldiers died in Iraq in World War I

Ancient Chinese records, as old as 2,700 B.C., show that in the East there was another disease which paralysed and rotted the muscles and turned men into living skeletons. In this there was no bleeding as in scurvy but numbness and paralysis. This disease began to be known as beriberi.

Nearly a third of the Japanese soldiers used to be on the sick list because of this trouble. About 1880 Takaki, Director of the Tokyo Naval Hospital, decided that it was not due to climate or sanitary conditions and suspected the diet. He sent two warships on a long journey. The *Ruyajo* had the usual rations, in which white or "polished" rice predominated. The *Tarkula* carried less rice but more barley, meat, vegetables and condensed milk. On the first ship about one third of the sailors suffered from beriberi, and several died of it. On the second only 16 out of 350 became sick and in every case it was shown that the sailor had not eaten his full allowance of the new foods but persisted in eating white rice.

The Japanese government immediately ordered that other foods be provided in addition to polished rice. Very soon the beriberi outbreaks became less frequent. For practical purposes this solved the problem. Yet neither Takaki nor anyone else knew the real connection between the altered diet and the reduction in deaths due to beriberi. Takaki conjectured that it was due to protein deficiency.

Towards the latter part of the nineteenth century the Dutch were rapidly infiltrating in the East Indies. In the island of Sumatra they fought against the Achinese, inhabitants of the northern part having their capital at Kotaradja. For a quarter of a century the Duch won many battles and yet they steadily lost the war. They had superior weapons but the army was torn to shreds by beriberi. Hospitals were rapidly built but were swamped in no time while the disease continued to increase in volume and intensity. This appalling condition caused the Dutch to write for help to their colleagues in the Universities of Leyden, Utrecht and Amsterdam The home Government sent a Commission consisting of several doctors who worked diligently in Java for nine months hunting for some microbe which may be responsible for the disease Since they failed to find any microbe they simply left instructions with the Javanese doctors to use plenty of corrosive sublimate to sterilise the rooms in the hospital. One member of the commission,Christiaan Eijkman (1858-1930), a former student of Robert Koch, was left to investigate the matter further.

Eijkman had studied with Koch in Berlin. He examined secretions, blood, and everything else trying to find a bacterium but failed. He tried the customary method of injecting sputum and blood from the patients into chickens but was unable to produce any symptoms of beriberi in them.

On one fateful day (June 10, 1889), his assistant came to report that the chicken feed had been exhausted. Eijkman asked him to see the head cook of the hospital who permitted him to use the remnants of the cooked hospital food. So from the next day the chickens began to get a civilised food consisting of nice, clean, cooked, polished, white rice. After a month peculiar symptoms were noted in the poor birds. Many of them became sick, emaciated and paralysed and could not even sit up. The disease advanced from legs to wings, tail to head, and slowly but surely ended in death. On November 20th, a new Superintendent arrived and being rather economy-minded he decided to stop the supply of the expensive white rice which was meant for patients and not birds and resumed the quota of the usual dirty brown crude rice. Lo and wonder! the sick birds rapidly recovered.

This was so impressive that Eijkman immediately gave up the search for a microbe and began to look into the food The experiment was repeated several times until he became convinced that birds eating nothing but polished rice always died from this strange paralysis (polyneurites) while birds eating crude, dirty, unpolished rice or picking their own food on the dunghill never got it.

This naturally led him to examine the brown skin on the rice. He made a decoction of it and forced it down the throats of the paralysed chickens. Within four hours they began to recover and were perfectly well next morning.

Now the mystery began to clear up. The Dutch soldiers had beriberi because they ate the most expensive polished rice. The Achinese ate the cheap crude, unpolished rice and were therefore free from the disease.

Experiments tried on labourers, prisoners and others fully confirmed this. In 1905 one Dr. Fletcher performed an interesting test on the inmates of a madhouse. The lunatics were lined up The even numbers were marched to the western ward of the asylum and fed on unpolished rice and the odd numbers marched to the eastern ward and given the usual polished rice A year later in the western ward there were no new cases of beriberi and no deaths, in the eastern ward there had been several deaths and most of the lunatics were sick.

The same experiment was made on 300 Javanese labourers, who were divided into two camps. In Camp A living on polished rice there were 20 cases of beriberi in less than 2 months; Camp B living on unpolished rice had none. Now the doctors reversed the diets. The patients of Camp A recovered while Camp B reported an outbreak. A similar experiment was tried on some 10,000 prisoners. There was only one case among those who were given unpolished rice, but 3900 among those who were fed on polished rice.

After this knowledge the beriberi hospital at Buitenzorg had little use; it was soon closed for want of inmates.

The explanation first offered by Eijkman for the production of beriberi during the consumption of polished rice was that the disease is due to a state of intoxication brought about by the consumption of excessive quantities of starch and that in the so-called 'silver-skin' which is removed by polishing there is a substance which counteracts the toxic products of the disturbed metabolism. This hypothesis was far-fetched and ingenious, but the conception of disease as the direct result of a specific deficiency in food was foreign to the thought of the time. It was somewhat later, partly owing to the work of others and partly owing to more extended experiments of his own, that Eijkman came to the definite conclusion that there is present in rice polishings a substance differing from the then known food constituents, but essential to normal nutrition, though required in very small amounts.

While Eijkman was busy with beriberi, there were chemists moving towards the vitamin mystery from an entirely different angle. They were not trying to cure diseases but developing the science of nutrition. There was a great craze for securing a concentrated ration which had enough of all the recognized food elements in it to keep soldiers going for long periods. They claimed to be able to make the purest of pure diets ("balanced bottles for bouncing babies") having exactly the right weight of carbohydrates, the right weight of protein and fat, and correct amounts of the appropriate mineral salts.

The chemists thought that at least they had perfected the whole business of food and feed. As a first step this synthetic stuff was tried on rats. They were surprised to find that it did not work. Children fed on such diet developed "Barlow's disease" which is a kind of infantile scurvy.

Since milk is the most perfect of all foods, in 1884 Lunin, pupil of the famous Professor G Bunge of the University of Basel, fed mice upon an artificial mixture of all the constituents of milk which were then known, namely protein, fats, carbohydrates and salts. He found that upon such a mixture the animals failed to survive and was forced to conclude that "a natural food such as milk must therefore contain besides these known principal ingredients small quantities of unknown substances essential to life.

Pekelharing (1848-1922) of Holland also came to a similar conclusion in 1905 and decided that there must be an unknown substance in milk which even in very small quantities is of paramount importance to nutrition. In the absence of this substance the organism loses the power to assimilate the principal parts o food, the appetite is lost and in spite of apparent abundance the animals die of want.

The famous biochemist F.G. Hopkins, of Cambridge, kept two sets of similar rats in different cages. The rats in cage I were fed enough prepared food in the form of protein, fat, sugar, and salts to be considered a balanced diet. Those in cage II were fed exactly the same diet, plus a certain amount of fresh milk. The rats in cage I lost weight and became ill; those in cage II increased in weight and remained healthy. In 1907 he further demonstrated that when small quantities of only some butter fat were added to the food it had a remarkably beneficial effect on the rats. Just as Eijkman had concluded that there was something in the unpolished rice, that prevented beriberi, so Hopkins was led to think that there was an "accessory food factor" in butter fat which had a definite effect on the health of his rats. Hopkins and Eijkman shared the Nobel Prize for medicine and physiology in 1929.

Meanwhile, E.V. McCollum at the University of Wisconsin was also carrying on feeding experiments on rats. He gave them measured and what he believed to be correct amounts of pure carbohydrates, proteins, fats, minerals and water. However, the rats developed an eye-disease, became sick and died. The experiment was repeated, but this time as soon as the animals became sick some were given a small amount of raw milk (3 ml. per day) in addition to their regular diet. These rats regained their health and became normal. It now became clear that raw milk contained some substance which was essential for the health of the rats. At first McCollum conjectured that milk supplied flavour to the diet which was otherwise tasteless and flat and disliked by the animals but later the beneficial effects were traced to the butterfat inside the milk.

Such observations greatly stimulated further research on these problems and in 1911 a Polish scientist, Casimir Funk separated from 400 Kg. of rice-polishings just a few grams of impure but tremendously potent crystals. Only a minute quantity of this substance could cure a paralysed chicken in three hours. He called it "vitalamine"—**vital** because it is essential to life, and **amine** because he considered it to be akin to amino-acids. This name was shortened to vitamine and then to vitamin.

Earlier in 1890, an English doctor, T.A. Palm, made some observations on rickets and pointed out that it was commonest in places where there was least sunlight and rarest wherever sunshine was abundant. He examined the remains of Egyptian mummies and found no evidence of rickets in their skeletons—thanks, he suggested, to the African sunlight. In the sunlit east purdah women suffered from osteomalacia, a gross form of adult rickets in which the skeleton becomes porous and collapses

Leonard Findlay, working at the University of Glasgow, found in 1908 how to produce rickets artificially in puppies He gave them nothing except a little milk and oatmeal porridge and kept them in laboratory cages. The animals failed to grow, their legs became deformed and weak, their chests compressed, ribs knobbed and spines curved The poor pups became quiet and lethargic. Another group, fed similarly but allowed to run about in the open, did not contract rickets and at first Findlay thought that muscular exercise must be the cause of the difference.

In 1917, Mellanby of the Medical Research Council of Great Britain tried to supplement the milk and porridge diet giving one thing after another but without any effect Finally he landed upon cod-liver oil and the result was spectacular. The warped bones of the pups became straight and strong and their broken spirits were mended They soon became frisky and active.

Another scientist at the John Hopkins University, named McCollum soon isolated from cod-liver oil the active substance which he called vitamin D.

At the same time German scientists found that rickets could be cured merely by sunbaths. Those who could afford these went with their children to spend the vacation in Italy, Spain or North Africa, but this was hardly possible for the poor. So they were exposed to ultraviolet lamps Within two months there was a remarkable effect. The babies were no longer weak, whimpering and apathetic creatures but became full to spirits and mischief.

The advantage of light clothing, shorts, open-neck shirts and bare legs is therefore obvious, for this causes the ergosterol in the body to become converted into calciferol. The old village custom of anointing babies with mustard oil and letting them play in the open is thus of great advantage in helping them to maintain their health.

The experiments of Eijkman, Hopkins, Funk, McCollum, and others had by now definitely established the presence in food of minute amounts of important substances. There followed a vast amount of experimentation which still continues. We now know of more than a dozen vitamins necessary to our health and general well-being. Some of these are available in the form of pills which we can use to supplement our diet. However, there may yet be many undiscovered vitamins necessary to us. For this reason, as well as for the sake of economy, it is better to depend on natural foods rather than on drug stores for one's vitamins.

There is an interesting old story in this connection about the London and Dublin zoos. It is said that the London zoo had enough money so that the keepers bought for their lions the kind of meat which human beings use, i.e., steaks and chops; yet the lions were weak and sickly. The Dublin zoo was short of money; so the keepers bought worn-out and old horses and used the entire carcass from nose to hooves, insides and all. The lions were healthy and full of pep, prancing and roaring The Londoners were puzzled at this difference. Travellers, who had been to Africa, knew that the diet of lions consisted of zebras. Now the lions did not eat just chops and steaks; they ate the whole zebra, the diet thus matching with that provided by the Dublin zoo. Among human beings the poorer folk who eat potatoes, skin and all, are healthier than the richer folk who eat them after the skin is peeled off. This is because the most valuable part of the potato, both from the point of view of starches and vitamins, is immediately under the skin. In peelings with the knife this part is thrown away and lost. Those who eat wheat should keep in mind that whole wheat (daliya) is better than flour and that the coarse brown flour is better than the fine white flour In the making of the latter the bran which is rich in vitamins, phosphorus, iron and protein is discarded. If a pigeon is fed on white bread alone, its wings droop and it soon becomes too weak even to stand up. If its diet is not changed, it will die. If, however, even after it is unable to stand, a little water in which the bran of the grain has been soaked is poured down its throat, it soon revives and becomes normal. When we reject the bran, we lose this essential substance.

Our present knowledge of vitamins teaches us that the care and cooking of food is as important as the choice of food if you want to have your full supply of vitamins. In general, exposure to oxygen destroys vitamins, and the higher the temperature the more rapid is the destruction. Vegetables should, if possible, not be peeled or cut up before cooking; the smaller the pieces the more the surface exposed to oxygen. Further, it is desirable to do the cooking in closed vessels because in this way air is excluded. And since water contains air until boiling drives it out, it is best to start the vegetables in boiling water.

Extreme heat, especially in the presence of oxygen, destroys some vitamins, particularly vitamin C and vitamin A. For this reason cooking should not be continued longer than necessary. You can thus save your health as well as your fuel.

Most vitamins, with the exception of vitamins A and D, are soluble in water. We should, therefore, use only small amounts of water in the cooking pot and whatever water is left should be kept and used, since vitamins (and minerals) are dissolved in it.

During recent years nutritionists have been interested in the possibility of fortifying or enriching certain foods that are most widely used. Nearly all oleomargarine in the U.S.A. is now enriched with vitamin A to make its nutritive value nearly equivalent to that of butter. Much of the flour and bread in the U.S.A. and Europe is enriched with niacin, riboflavin and iron. For the poorer people of the orient the best policy is to use brown rice, whole wheat (or coarse flour), unpeeled potatoes, and as much of fresh fruit and vegetable as possible. And the cheaper fruits and vegetables like *ber, jamun, methi, palak, bathua*, etc., are often as good as or better than the costlier ones. Also, as explained before, except in the winter it is best to put on as few clothes as possible. Neckties, socks, long-sleeve shirts and jackets may be signs of civilization, but in a climate like ours they do positive harm to health.

At present about 18 vitamins have been distinguished and their number is continually increasing. Not only their physiological effects but chemical compositions and constitutions have also been ascertained. As to their chemical action, vitamins are either coenzymes, in the absence of which enzymes cannot act, or they are constituents of coenzymes.

HIGH SCHOOL SCIENCE TEACHING IN THE NUCLEAR AGE

B. D. NAG CHAUDHURI
Saha Institute of Nuclear Physics, Calcutta

Our lives have become complicated and exciting with the advent of the radio, the television, nuclear power, atom bombs and many new inventions. We, as citizens, are discussing many aspects of these inventions as they affect our lives and our social systems. Five-year plans of our Government decide growth of electric power, and nuclear power plants; they bring into being new technologies and industries such as optical glass and microscopes. Yet these fields of science which embrace many human activities and are the basis of much social and political thinking remain outside the range of interest of school and college science. Our tomorrow's citizens are being brought up in ignorance of issues in which they are expected to exercise responsibilities and make vital decisions

This problem really devolves on the teachers of our children who are now in high school. Because of their lack of background and vitality, they are in large measure unable to incorporate intelligent appreciation and basic knowledge of the new developments in technology and science into their immediate teaching interest. It is not surprising that lively and intelligent interest is not created in our pupils about the technological world they live in.

Another problem for young students of science is a product of the fact that inter-disciplinary sciences have grown into major fields of human endeavours. The borderland sciences have wiped out separation of disciplines. Students who have been educated in the narrow disciplinary sense of the sciences find it difficult to appreciate the excitement of such interdisciplinary technologies and sciences as nuclear technology and space science.

These are problems in the teaching of school science in every nation, and science teaching in each country is attempting to change its science education to face the exciting challenges of the age.

BORDERLINE SCIENCES

The disappearance of the dividing line between the sciences such as physics and chemistry and biology, unfortunately, becomes apparent to the student in our country very late in his career. The student in school and college toils at separate compartmentalized sciences. Can we endeavour to give to the students in our high schools magic spectacles which will extend his vision to distant horizons and his appreciation of how in recent years many sciences have extended to merge into one another ?

For example, the story of the researches of scientists investigating the structure of the nucleic acids in the cell nucleus and their relationship to heredity and other cell properties grew out of the work of biochemists, biologists and biophysicists. It can be an enthralling tale to a school student who is usually well able to grasp the essential patterns of cell division and the role of the nucleic acids without being able to understand details of many facts and arguments. The reality of space travel has brought to astrophysics new knowledge of the solar system and a sense of adventure as exciting as any pirate's tale and it can be made so to the students with little effort from the science teacher.

Our science teachers, whether in school, college or university, have the responsibility to bring to our boys and girls while undergoing their education a realisation of these vast horizons and a sense of excitement and participation in the world of tomorrow to which they will belong. There is no unique way of doing it. Not only each country or Government but also each school and college, each teacher, headmaster and principal has to analyse the functions and objectives of his teaching programme and gauge the level of interest of the students. It is through such endeavours at many levels that each teacher and each school will find out what it can do successfully and how far it can create or increase the level of interest in technology and science not only as useful disciplines but as philosophies of an approach to life. It is in this context of an exciting technological change that our national objectives can be made comprehensible to students whether it is nuclear technology, hydroelectric power or production of jet air planes.

CURRICULUM AND THE TEACHER

After independence, general science or rather everyday science has been introduced in the primary and middle school curricula all over India. Physics, Chemistry and Biology have been incorporated as optional subjects in the higher secondary syllabi by almost all state education departments. These are vitally necessary steps to reorient our school education to fit with the modern world of science and technology in which our country has to be a viable member. However, they are not in themselves sufficient. It is the science professor or teacher who has not only the responsibility of communicating to his students facts and methods but also of creating a sense of universal participation in the drama of science and technology as a part of the totality of human endeavour. Such a responsibility calls for teachers who are not only knowledgeable in one discipline but have in addition a wide background and imagination. Such a teacher, ideally, even though he is teaching science at an elementary level, should have good advanced training, that is, at least, the M.Sc. level.

This will be clear, if we enquire into the usual preparation of the average teacher. He is perhaps an M.Sc in Physics, Chemistry or Mathematics. Suppose we take an average M.Sc in Physics. He has some B.Sc., background in Mathematics and Chemistry of about six hours a week for two academic years. This is insufficient background in the subsidiary sciences for effective teaching of physics. While he might be able to follow the well-marked path of the syllabus, it is too much to expect him to plan his class or laboratory work effectively to inspire the superior student and to bring about an appreciation and insight to the average student. Actually the science teacher is saddled with the many deficiencies of his education in college or university where facts of science are given importance. He has not had the advantage of counselling or discussion of ideas with his teachers and colleagues. I have mentioned, obliquely, the role of the history of science in teacher preparation because of the important role it plays in developing social attitudes. The insight that such study can give to the teacher and through him to his students in understanding contemporary problems and ideas is valuable and in our country entirely missed.

Experiments are looked upon in most of our teaching as verification of statements made by the professor or teacher. The very nature of experiments as a search for truth is missed. That the generalised human hand with its opposable thumb is as much an organ of acquiring knowledge as the eyes and ears, is hardly ever appreciated.

One way to meet this problem is additional preparation of the teacher. His school and the state should encourage him in every way to obtain this needed background. Such added preparation can be in the form of formal class work or in some areas at least as part time work in the evening and holidays. It must be remembered that our teachers in addition to a full schedule of teaching, have to supplement their income by private tuition work and other off-time employment. Encouragement may be given by subsidizing the teacher to some extent and lessening his non-teaching school duties. It is only the mature and well-grounded teacher who can make the elementary sciences exciting and informative. Unfortunately, in many cases now-a-days, the texts and teacher's presentation at the elementary level tend to repel students with false ideas of difficulties rather than excite or enthuse them. The science teacher should have interest and zest in the adventure of modern science and its impact on technology and society. To make the adventure of science real to the students, the teacher should have cheaply and in profusion science apparatus and tools outside the class work, and standardised experiments. These, to some extent, can be made the purpose of added teacher preparation.

PREPARATION OF THE TEACHER

The added teacher preparation envisaged is not necessarily uniform for every teacher or every region of the country. I am conscious that the tentative suggestions on the preparation of high school teachers of physics made here are not free from criticism and they should be considered as preliminary suggestions only. For the physics teacher the following subjects are recommended: physics, chemistry, biology, related sciences and mathematics.

The contents of the subjects may be something like ·

Physics : Modern Physics :

Atomic and nuclear physics phenomena, concepts and experiments. (Aim is understanding and appreciation rather than a large volume of matter).

Electronics :

Mathematical knowledge of higher secondary mathematics courses should be utilised only in the preparation stage.

History of Physics :

Uses and technological consequences of physical discoveries.

Chemistry :

Organic, bio- and physical-chemistry with emphasis on the principles which unify the many facts of chemistry with physical principles. History of Chemistry.

Biology :

The organisation of the cell. Evolutionary theories and facts about meiosis, mitosis, mutation, structure and the role of the nucleic acids in the nuclei.

Related Sciences :

Elements of geology, meteorology, physical geography and astronomy.

Mathematics :

Modern mathematical ideas. Their uses in the sciences.

Laboratory methods and techniques connected with electronics, hobby shops, simple machines and shop and laboratory lay outs.

It is an unhappy fact that many teachers at least in physics are called upon to teach with little or no preparation. In the hands of a poorly prepared teacher, the courses degenerate into routine reading of texts and working out of problems by substituting numbers for letters in algebraic formulae. Question are unwelcome. Laboratory work when undertaken is 'cook-book' style. If it is frustrating for the pupils it is even more unpleasant for the teacher. No matter how conscientiously he may try, he 'has a tiger by the tail'. He finds his self-respect evaporating. Such experiences leave permanent scars on both teacher and students. The teacher needs desperately the support of his colleagues and their encouragement. To some extent, the inexperienced and poorly prepared school teacher can be helped to overcome his handicap by the head who might assign a part of his professional load to another teacher of known skill and experience. Perhaps such a person can be found in the neighbouring college or university or amongst industrial physicists or engineers, who are aware of the current problems in physics teaching and can be counted on to show a helpful and sympathetic attitude. Regular consultations with such persons dealing with the planning and progress of the course and particularly with the laboratory preparation and handling of equipment is essential. Ideally, the objective of a science course is not only the curricular material but the cultivation of a scientific and rational attitude to our social and educational problems in the students as a product of our science teaching in schools.

NEW CONCEPTS IN SCIENCE

The nuclear age has brought into being powerful methods to study many gross or macroscopic phenomena. The applications extend to almost every field of science and technology. For this reason the beginning courses in physics even at the higher secondary stages may no longer avoid entirely the study of atomic and nuclear phenomena. The basic facts of atomic and nuclear phenomena are avoided in our presentation today until the last stages of college education as though they were after-thoughts or luxuries in the strange belief that such ideas are difficult. When the physicist introduces the concepts of force, energy, conservation laws of momenta or mass, electrical charge etc., he can without much difficulty expand his horizon beyond the inclined plane and the eletroscope. The atom itself offers an exciting frame of reference through which many basic physical principles can be illustrated in a manner that is as exciting and illustrative as falling projectiles. Recent teaching experience in high schools in the U.S.S.R. and the U.S.A., have shown that students easily accept such new concepts. It is difficult only to those who have been brought up on ideas which are different and which have to be discarded or unlearned and new ideas have to be accepted in their place. Of course, in the beginning the student is not prepared or equipped to deal quantitatively with atomic phenomena. It does not matter, for, a teacher with adequate back-ground can attempt a descriptive picture of the dynamics of the atom, resisting the temptation to hide the beauties and mysteries of the atom behind forbidding mathematical equations. Rigorous reasoning and even quantitative illustrations can be introduced wherever possible at various points along the way. Similarly, in the teaching of chemistry his approach need not be frozen to that of half a century ago. The world of atoms can be thought in terms of a dynamic system of building blocks which will include many hundreds of stable and unstable isotopes.

NEW TEXT BOOKS

The difficulties of the science teacher is aggravated in our country by the lack of improved texts in physics or chemistry having such expanded objectives in mind. A particular need is to develop new books for the teacher as well as the taught, delineating the marvellous world of physics and chemistry and all that can be done with simple things in school and home to give our youngsters a better appreciation of the science of physics and chemistry as it affects our lives and that of the rest of the world today. Books which can spark appreciation for force and temperature phenomena that today accompany artificial satellites and nuclear power, will give the student some idea of the challenge that the future holds for him and his generation. There has recently been attempts in the U.S.A., U.S.S.R. and U.K. to produce books through collaborative efforts of scientists, school teachers and educationists. However, this has always to be supplemented by other source materials such as pamphlets, magazines, journals, slides and films whenever possible and they should be available easily and cheaply.

It cannot be argued, as is sometimes done in our country, that students of ages 12-16 are not receptive or capable of comprehending complex ideas and their relationships. The U.S.S R. school system has demonstrated what large doses of languages and mathematics can be imparted to students in this age group. The U.S.A. soon after the first Soviet artificial satellite went into orbit, began looking closely at their school science education. Through the participation of the university teachers of several universities, professional groups such as the American Institute of Physics and the National Science Foundation have investigated the problems of school science in the U.S.A. They have found that young boys are fully capable of appreciating complex ideas and their logical consequences, if the presentation is suitably made. The inhibition of students arises mainly because of the presentation of the subject matter and not the matter itself. In schools such as the University of Illionois High School (known as Unihigh) sponsored by the University of Illionois, university teachers and those of the school work together to try out the best ways of teaching according to the students' capacity for learning. Their findings are extremely interesting and bear detailed study. The importance of presentation, the processes of familiarizing students with ideas and concepts are as important in teaching as the concepts themselves. Children, boys and girls, who have not developed preconceived notions, grasp revolutionary ideas far more easily. It has been found that the process of learning and unlearning physical ideas that our school curricula induce because of layer-wise presentation of the subject actually inhibits the students from accepting ideas on the evidence given. The great need today in our country is the removal of the process of unlearning in our science education and the development of interesting methods of presenting facts.

The social and economic disabilities of teachers have been discussed in the press and elsewhere. Apart from social disabilities, school teachers suffer from the disadvantage of having to work in a milieu which is intellectually very narrow and confining

SUMMARY AND CONCLUSIONS

We can sum up the problems of science teaching as partly curricular and partly that of social atmosphere. The curricular problems basically are:

(1) those concerned with the presentation of the subject particularly layer-wise presentation which involves learning and unlearning;

(2) the absence in the content of teaching of the stimulus of modern progress and the adventure of science as well as its impact on our environment.

The problems of the teachers in relation to the social milieu are :

(1) social and economic disabilities of the teachers;

(2) narrow and unstimulating intellectual atmosphere in which they have to move.

We cannot hope to suggest practical solutions to problems of such wide and varied proportions. No country has completely solved any of these problems. In fact the consensus of opinion in countries like England, America and Russia today are that the school curricula including school science and its presentation are continuing problems. One only obtains better solutions, one does not try to achieve a final solution for all the time. Most of the measures that are now being proposed in the County Council Schools in England strongly reflect this approach. The work of the National Science Foundation in the United States is also based on the philosophy of continuing efforts. The economic problems of the teachers are associated with the financial resources of the country and can only be solved progressively. The social disabilities are a growth of recent origin not unconnected with developing industrial economy and city life. This part of the problem, even if it cannot be solved, can to some extent, be mitigated by continuous and persevering efforts of teachers and teaching administrators of all groups. One particular approach is that of setting up regional councils or counselling committees or boards. These boards composed of teachers of schools, college and universities as well as teaching administrators can try to improve the narrow intellectual atmosphere that surround the schools today. Such counselling committees working on a base of social equality can, to some extent, work continuously for a better intellectual and social atmosphere and bring into being, in our entire educational pattern, the stimulus of scientific adventure and its social impact through discussions, meetings, social intercourse and by experimenting with various suggestions. Success in any measure can only come by rigorously avoiding in such counselling committees any attitude of social and intellectual inferiority in the school teachers.

Some efforts have been made recently in our country to detect and encourage science talent in school boys and girls. Here too, the co-operation of school teachers can increase the scope of investigation regarding the early influence of the home and the school as factors in producing talented students and factors that may encourage it at school. Such investigations by teachers might increase their sense of participation in the various efforts to encourage science and technology in our country.

However, it is important for us to emphasize that the problem of teachers has to be equated to the problem of school reform. It is difficult, almost impossible, to increase the content and value of school science without at the same time doing anything to improve the social and intellectual life of the teachers.

FLIGHT IN BIRDS

VISHWA NATH

University of Punjab, Chandigarh

No single group of vertebrates (=animals with a backbone) has made such a complete conquest of its environment as the birds have of the air in which they live. Furthermore, the resultant modifications are so profound and so delicately balanced that there does not seem to be any scope for further specialisation in that direction. This is clear from the well-recognised fact that, in spite of the profound modifications in the anatomy of a bird, its organisation remains singularly uniform throughout the group The student may pause and think of the remarkable phenomenon of adaptive radiation met with in such vertebrates as the fishes (especially the bony fishes), reptiles, both living and extinct, and even mammals; but in contrast to all the astonishing and bewildering diversity of form and structure met with in these groups, the organisation of a bird has remained constant and uniform throughout the group ever since this delicate balance of profound adaptive modifications was achieved.

These modifications related to flight are correlated and are delicately balanced; in other words they have taken place simultaneously though slowly.

STRUCTURE OF WINGS

The greatest need of birds is to fly in the air, which they have completely conquered. Even a layman knows that birds fly with the help of a pair of wings. Now what are these wings? The wings are modified fore-limbs. Indeed they are in their fundamental structure, exactly like your own fore-limbs. But while your fore-limbs are modified for swinging (particularly the limbs of the apes—our ancestors) and grasping, the fore-limbs of a bird are modified for flight. But through both runs the same fundamental plan—an upper arm containing a single long bone called the **humerus**, a fore-arm containing two long bones called the **radius** on the inner or preaxial side and an **ulna** on the outer or postaxial side, a wrist containing two rows of small bones called **carpals**, a palm containing in our case five comparatively long bones called **metacarpals**, and five fingers, each containing three small bones called **phalanges** except the thumb which has two. Such a limb is called pentadactyle, i.e., a limb with five digits.

But the fore-limbs of a bird are greatly modified as they have to function as wings. In the first place the wings of a bird are covered with feathers by virtue of which, in action, it becomes an impenetrable parachute to displace the air. Indeed almost the whole body of a bird is covered over by feathers. Feathers are highly characteristic avian structures, just as hairs are characteristic mammalian structures.

The skeleton of the fore-limb of a bird is highly modified. In the first place, the metacarpals of a bird (say fowl), of which there are only three (I, II, III, nos. IV and V having disappeared), have fused indistinguishably with the second row of carpals to form a characteristic avian structure called the **carpo-metacarpus.** Again the number of phalanges in the fingers (of which there are only three as there are only three metacarpals) is greatly reduced. The first finger bearing a single pointed phalanx along with the first metacarpal is greatly reduced; the second finger bears only two phalanges; and the third only one

The parts of the wing described above are folded, in the position of rest, against the trunk in the form of a Z; during flight, however, the wing is straightened out and stretched on the side of the trunk so as to make a right angle with it. A fold of skin, the **prepatagium,** stretches between the upper arm and the fore-arm on their preaxial border, and a similar but much smaller fold, the **postpatagium,** stretches postaxially between the proximal part (= the part towards the trunk) of the upper arm and the trunk.

You must clearly understand that although the fore-limb of a bat is built on pentadactyle plan, its wing is entirely made up of an extensive fold of skin (patagium) which includes the extraordinarily elongated bones of the fore-arm; the patagium is elastic and firm and forms a very efficient parachute for flight. Again there are no feathers in the bat. Indeed the bat is not a bird. On the contrary it is a mammal, as it possesses hair and various other mammalian features, the most important of which are (1) the possession of **mammary glands** by the female which secrete milk for the nourishment of the young, and (2) the long period of **gestation** during which the foetus remains in the uterus (womb) of the mother before birth and is nourished through the blood of the mother.

Now the bird requires powerful muscles to depress and raise the wings for flight; such powerful muscles, the **pectoral** or **breast muscles** do exist in a bird. You know that the breast muscles of a bird are considered a delicacy by man. Again, to accommodate the breast muscles, which move the wing, you require space. You know that your breast bone, or the **sternum,** as it is called, is flat and is hardly covered by muscle, but the sternum of a bird has a keel like that of a boat; the space for the attachment of breast muscles is thereby greatly increased. The wing is lowered by the action of a huge muscle called the **pectoralis,** which fills up nearly the whole of the space on each side of the keel of the sternum, closely applied to that bone. The fibres of the pectoralis are inserted on the ventral (lower) surface of the humerus; consequently when this muscle contracts the wing is depressed. Curiously enough, the wing is not raised by the action of a dorsally placed (placed above) muscles but by the action of the **subclavius** which arises from the anterior (front) part of the body of the sternum, dorsal to (above) the pectoralis. The tendon of the muscle is given off upwards; it then passes through the dorsally placed **foramen triosseum** (a hole between the ends of three bones, viz., humerus, and coracoid and scapula bones of the pectoral or shoulder girdle to which the humerus of the fore-limb is attached) to be inserted on the dorsal surface of the humerus. This hole acts as a pulley; when the subclavius contracts, its tendon is pulled backwards (and not forwards) on account of this pulley-like arrangement, and the humerus is raised. Again, there are special muscles called the **tensores patagii,** whose action keeps the pre- and post-patagium well stretched during flight.

Again, you want some mechanism in a flying animal to enable it to change its direction of flight. This is provided by special stiff tail feathers, the **rectrices,** for steering the animal during flight; these feathers are attached to the hind end of the backbone which is modified into a short, stumpy tail, the **uropygium.**

In front, there is a comparatively long mobile neck, at the distal end of which is perched a short head with a well-developed beak, there being no teeth in a modern bird.

During flight the hind-limbs are tucked under the abdomen.

The bones of a bird are very light on account of the presence in them of air-sacs connected with the air-tubes (branches of bronchi) in the lungs.

On account of these air-sacs which are present elsewhere also in the bird, the animal is capable of taking in a lot of oxygen for respiratory purposes, i.e., for the oxidation of tissues This high rate of oxidation releases lot of energy for flight, and also heat. Therefore birds are warm-blooded animals and they have a constant temperature, which is even higher than that of mammals, being well above 100 F.

Finally, the body of the bird is streamlined; there are no projections to offer resistance to the air during flight.

[To be continued]

SOME MUSINGS ON THE TEACHING OF SCIENCE

K. MITRA

Jagadis Bose National Science Talent Search, Calcutta

Science has come rather late in our educational scheme and therefore, it had and still has to encounter the difficulties usually experienced by any fresh innovation to fit into any traditional or set pattern of things. The subject had to be accepted in the school curriculum because of the place science takes in our everyday life in spite of all the recent controversies about its possible or probable misuse. As science has to be developed for human welfare there is no other alternative than to make the utmost use of the human material available in the country. Consequently, the point to be decided is how the teaching of science can be made effective and useful.

Many a scientist with considerable experience as a teacher holds the view that for effective teaching of science, scientific attitude has to be developed at the age when the child's interest in his surroundings has not been inhibited by social conventions, and when the chance of stimulating in his young mind a sustained interest in the newer horizons of life, have not been lost. A recent study report of the American Association for Advancement of Science advocates that science education should start in the kindergarten stage, the reason being that 'basic attitudes, patterns of thinking and modes of behaviour' are formed during early years.

SCIENCE EDUCATION

Objects

The objects of science education in schools should not only be to train young impressionable minds with the systematized knowledge which is useful and practical, but also to develop in them a scientific attitude to life and the environment. In the earlier days, and probably still today to a measurable extent, too much of stress had been and is being laid on making the student commit to memory theories, formulae and an apparently uninteresting mass of information without trying to arouse a curiosity in his mind towards science and the benefits conferred by science. The teaching methods have to be slightly reoriented. The student should gradually be made to realize the fundamental fact that science is the system of behaviour by which man acquires mastery of his environment. Everybody agrees that scientific facts, concepts and principles should form part of the basic education so that everyone may live more effectively in his natural environment. Unfortunately, however, it is not uncommon to come across students in science classes at the school level who have no idea as to why subjects like physics, chemistry or biology are being taught, or what each subject stands for. It is hard to ignore the fact that to a novice the way of introduction to a discipline determines to a very large extent his future interest in the particular subject taught.

I vividly recall the thrill I experienced in the first year of my college when my science teachers, of revered memory, did not deliver any lectures for the first three or four days, but demonstrated during lecture hours (in the physics class), the workings of the portable model of a steam engine, the electric shock experienced from Wimshurst machine, ringing of a calling bell with the help of an electromagnet, and water rushing out of a siphon. The teacher in chemistry also kept us spell-bound by displaying the changes of colour induced in the indicators, (most of all the colourless phenolphthalene becoming red), by the alternate use of acid and alkali solutions, the explosion caused by a mixture of oxygen and hydrogen in a bottle made of thick glass covered all round with towel and held near a Bunsen burner, the increased glow of a lighted charcoal inside a glass jar containing oxygen, bubbling of gas from a Kipp's apparatus, a small jet of ignited hydrogen as prepared from an Wolfe-bottle making sonorous noise inside a glass tube, and water from the glass trough spontaneously rising in an inverted glass jar containing water soluble ammonia gas.

After a series of these preliminary demonstrations interspersed with brief explanatory talks, covering three to four lectures, we were told that physics deals with energy in its various forms and chemistry with the properties of matter. It did not detract from our preliminary concept of physical sciences even if we were kept ignorant of the theory of the conversion of mass into energy. I wonder if such preliminary demonstrations wasting (?) three or four lecture hours are delivered now. It is quite possible that the students in the first year class in the colleges today are more sophisticated than we were 45 years ago. No doubt, times have changed. We cannot ignore the basic fact, however, that science teaching today begins in the higher secondary classes in the schools, and rightly too, at an age when the students are mentally less mature than a first year student of a college even twenty years ago. While listening to the various properties of nitrogen gas the attention or the interest deepens if the teacher lays a special stress on the point that though the gas is colourless, odourless and apparently uninteresting, it is an essential component of all living material. The very idea that life without nitrogen is not possible may help in promoting a healthy respect for this particular element. Innumerable instances like this could be cited. The student may find his task of memorizing scientific details worthwhile if it be explained to him how a particular theory or formula can be helpful to him in the future or has helped the progress of science.

History of Science

It appears pertinent in this connection to make a few observations on the importance o" the history of science. This is an aspect of science teaching which has yet to receive its due recognition in the syllabuses for science teaching. For the last quarter of a century a number of interesting and useful publications on the subject have appeared in the market. For developing the proper scientific attitude short anecdotes of the various scientific discoveries pertaining to the subjects taught are essential. A politician and an author of international reputation whilst recounting the difficulties he had experienced in the school in picking up the teaching in classical subjects, has very aptly observed, "Perhaps if I had been introduced to the ancients through their history and customs, instead of through their grammar and syntax, I might have had a better record." It may said without contradiction that, if in the learning of classical languages, or as a matter of fact any language, a rudimentary knowledge of the history and customs of the people using the language is necessary, it is more so in learning science subjects. It is by no means suggested that the existing syllabus be over burdened by the inclusion of another item, namely, the 'history of science'. Small anecdotes pertaining to various scientific discoveries or the events leading to them, at appropriate places, are likely to enliven the theoretical lectures.

Demonstrations

It is admitted on all hands that no matter how interesting the lecture on experimental science subjects, it fails to make any lasting impression unless accompanied by suitable demonstrations. The essential prerequisites for proper science teaching in any educational institution, apart from qualified teachers, are the necessary instruments and equipment and practical class rooms, where the students can try and see things for themselves. During the last 15 years there has been an enormous expansion of science teaching in the schools and colleges without any tangible efforts being made, until recently, for making readily available supplies of instruments and appliances. The net result is that a large percentage of secondary schools do not possess the necessary stock of these essential aids to teaching. It it heartening however to note that the Government of India, and the Planning Commission are seized of the problem. The requirement of science instruments of different types has been assessed by a special committee with the result that the Central Scientific Instruments Organization under the Council of Scientific and Industrial Research came into being in October 1959. There has been appreciable improvement in the situation during the last few years. Much will depend, however, on how quickly the desired results are achieved.

Improvising Equipment

The non-availability of a particular type or types of instrument or appliances for demonstration should not make us despondent. History tells us that men in the past have made the best use of their ingenuity under unfavourable environment and distressing circumtances. For example, the world owes the development of synthetic (ammonia) fertilizers, the sugar from beet root, and the synthetic fat from coal (Fischer Tropsch process) to the conditions of scarcity and blockade caused by wars. Consequently, a realization of the present difficulties and the knowledge that something needs to be done, it is hoped, would encourage and stimulate our school authorities, not teachers alone, to meet the challenge. With the notable exception of optical and a few other precision instruments some of the others can with a little resourcefulness be improvised or locally made. If a crude substitute can help the students to understand any scientific technique its finish or appearance is of no consequence During the critical period we are facing we can neither ignore the saying—necessity is the mother of invention—nor the possibility of exploiting fully the abilities of the indigenous carpenter, iron-smith or tin-smith, in short, the locally available technicians.

A visit to the annual exhibitions organized during the last four years, under the auspices of the All India Science Teachers' Association will convince anyone that the suggestions made in the preceding paragraph are practicable and that there is no dearth of talent in the country for improving instruments and appliances for science teaching. Exhibits accepted for display at the conference comprise the efforts made by the students, the teachers, or jointly by the students and teachers. Prizes are offered to the competitors adjudged to be the first and second best in each of the three categories The unfortunate fact which looms large is, that the secondary schools of only a few of the States in India have taken this activity seriously Here is an instance where the latent scientific and technical talent yet remains untapped, whatever may be the reasons behind it.

Role of Science Clubs

Persons interested in the progress of science education in the country are also aware of the science club movement initiated during recent years by the Extension Directorate of the Ministry of Education, Government of India. If this movement receives the encouragement, financial support, material help and full co-operation from the State Governments, the school administration, the teachers and, the last but not the least, donation from the members of the public, it is likely to go a long way in improving our standard of science education by overcoming many of the lacunae referred to earlier, and arousing in the young minds the spirit of curiosity and love for science. But the information available indicates that response from school authorities falls far too short of the requirements, even on a modest estimate. It would be idle to expect that in a limited space of four or five years we can catch up with the standard of western countries. But if the number of science clubs over the whole country does not exceed the figure 500 in four years, the reasons for slow progress need closer attention.

This is no place and the author pretends no competence to go into the reasons responsible for the chequered career of this important national venture. A frank exchange of views with some of the school authorities and Extension Directorate and officers in outlying areas is likely to convince any unbiased observer that the difficulties, though varying at times from school to school, are not insurmountable. We all realize that the hands of the State Education Directorates all over the country are full at the present moment on account of the tremendous increase in their responsibilities resulting from the successive Five-Year Plans. Probably we are trying to do too much all at once. The upsurge for progress in the post-independence era has put a strain on the resources in the country. Nevertheless, if there be a question for priorities, the science club movement deserves a very high one, because it is likely to create conditions in which investments or expenditure on spread of science education from the public exchequer can bring in greater and surer dividends.

SCIENCE IN THE DAYS OF AKBAR

U. S. NIGAMA

Modern School, New Delhi

The study of the development of scientific knowledge in schools and colleges is only of recent growth, and in our country it was even more delayed. Its usefulness needs no advocacy.

A detailed history of the development of science in India will be a monumental work Right from the dawn of history, there are visible proofs even today that science did maintain a place of its own in the country. It is the intention of the present writer to bring up some interesting facts regarding the development of science during the reign of Akbar.

In the court of Akbar, Abul Fazal occupied a place second to none not only in state craft and diplomacy but also in various intellectual undertakings. His famous book **Aayeen-e-Akbery** is perhaps the most authentic account of scientific development in Akbar's regime.

The study of science in Akbar's reign is of special significance. It shows that his empire was not entirely a military establishment. During an era when even the patronage of great minds by monarchs depended on military stability of the patron, it is not surprising that Abul Fazal showed such a keen interest in the arms and armoury of Akbar. Abul Fazal has written at length of the mughal armoury and the king's interest in it. He has also made a mention of the manufacture of guns, etc.[1] Yet the major part of his book is on achievements of science in peace. In a militant age it is heartening to find that almost all branches of science came under the perview of Abul Fazal.

A probe into the book[2] reveals very interesting facts about scientific knowledge in that period. Most of the knowledge had been inherited from Indoos and Arabs, but its mention in this detailed form is clear indication of the fact that people in that age were conversant with such knowledge.

The following may give a glimpse to the reader about the progress of natural and physical sciences in those days.

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[1] He is silent about the manufacture of explosives. Perhaps these were imported.

[2] The author has made use of an English translation of Ayeen-e-Akbery, rendered by Francis Gladwin.

Aayeen-e-Akbery contains a chapter on science. But all the information or relevant facts are not to be found just at one place. These appear scattered here and there throughout the two volumes. Correlation or sequence of topics seems to have been of no consequence to the compiler of this great book. In those days knowledge was not subdivided into compartmental heads like mathematics, physics, chemistry, etc. It was treated as a whole and the learned knew quite a lot of every thing, while they were masters of some specific topics. We may safely presume that Abul Fazal knew a great deal of what he has written His study must indeed have been vast.

MEASUREMENT OF LENGTH

To start with, let us see what were the three fundamental units of length, mass and time prevalent in those days. What were the standards in use?

Regarding the different kinds of measurements of length he writes,

> "Sultan Secunder Lodee invented a Guz in Hindustan, consisting of the breadth of forty one iscundrees and a half which was a round silver coin adulterated with copper. Hemaioon made it complete forty two escundrees. This Guz is equal to thirty two fingers; but according to some ancient authors, this Guz was in use before the time of Lodee.
>
> "Sher Khan fixed the crouh (Kos) at 60 jereebs each containing 60 iscondree Guz; and this rule is still observed in the suba of Delhi.
>
> "In Gujerat a crouh is the greatest distance at which may be heard the ordinary lowing of an ox and this is estimated at 50 jereebs. . .
>
> "In Bengal they use a Depeyeh crouh, which is the distance a man can go at a quick pace without being out of breath.
>
> "Some Hindoos reckon the cose (Kos) to consist of 1,000 steps made by a woman carrying a jar of water on her head and a child in her arms."

From these we see that the standard for the measurement of length depended on the natural corn of the 'barley' and only in one case on the stable and easily comparable diameter of a coin, the 'iscondree'. Only in this case do we find a standard reference available to avoid inequities.

> "His majesty taking into consideration the inconveniences arising from a multiplicity of measures commanded that for all purposes there should be used only one Guz, consisting of forty one fingers, and named it the 'Ilahee Guz'. . .
>
> "The measurement of roads for the ascertaining of distances being an object of Public Utility, His Majesty has given great attention to it and has caused distances to be measured in crouhs each consisting of 100 Tenabs of 50 Alaiy Guz; or 400 Bamboos of 12¼ Guz each By either of this method a crouh (Kos) contains 5,000 Guz."

The above gives us very interesting examples of a Guz and a cose or crouh (Kos) both of a flexible and a fixed type. Certainly such measurements of length depending on human or animal effort or on the thickness of animal hair or the size of a certain corn, must have been highly unscientific, apart from all the inconveniences involved in using them. Just as human or animal effort will vary from individual to individual so would the thickness vary from hair to hair and from corn to corn.

The following tables taken from the book give some information about the multiples and sub-multiples of the units of length.

6 Hairs of a mule's tail	Make one	Barley corn
6 Barley corn		Inch
24 Inches		Guz
4 Guz		Bagh
12,000 Baghs		Mile (Meel)
3 Miles		Fursukhs
2 Fursukhs		Bereed

"According to Hindu Philosophers

8 Barley Corns Stripped of husk	Make one	Inch
24 Inch		Dust (or Cubit)
4 Dust		Dund (or Dehnuck)
2,000 Dehnucks		Crouh (or Cose) (Kos)
4 Cose		Jowjun" .

The knowledge of π, the ratio between the circumference and a diameter of a circle has been attributed both to the Hindu and the Greek.

> "The Hindus were not ignorant of the rule which has been handed down among the Greeks from Archimedes: which is that the circumference is to the diameter as twenty two is to seven. . . .
>
> "Also, it is evident that the Greeks were ignorant of the Hindoos rule, for if they had possessed it, they would not have failed to mention it. . . .
>
> "The diameter being multiplied by 3,927, the circumference is to be divided by 1,250 when the quotient will be circumference of the circle."

These figures when worked out give the value of π as 3.1416, correct almost to the fourth decimal place, as compared to the present accepted value.

MEASUREMENT OF MASS

Like the standards for the measurement of length, there were a number of weights prevalent in the country. Also different weights were used for different purposes

For bigger measures the present Indian weights, the maund and the seer were in use, and for smaller masses, tolah, mashah and the ratti were in vogue.

In addition to these, there was the **miskal**—a weight used in measuring the mass of gold.

> "From the ancient record of some monasteries it appears that the Greek 'miskal' has been for a long time discussed, and it was two keerat less in weight than this. Here we find a comparison of Indian weights with those of the West, suggesting the existence of trade in valuable metals between India and countries of the West."

An idea of **miskal** may be had from the following table.

6 Mustard seeds	Make one	Barley corn
2 Barley corns		Habbeh
2 Habbehs		Tessuj
4 Tessuj		Dang
6 Dangs		Miskal
12 Zeerahs		Kitmeer
6 Kitmeers		Nekeer
6 Nekeers		Feteel
6 Feteels		Ful
12 Fulls		Mustard seed

These two tables give us a fair idea of the submultiples of weights. The accuracy that was aimed at was up to 30 thousandth part of a mustard seed. From the table one Zeerah works out to be equal to $\frac{1}{31104}$ of a mustard seed.

Yet there is no indication of a standard mass being preserved anywhere. What measures the state took to standardise weights and to have a check and control on them are not indicated. Any evidence to this effect is also lacking about the standards in length. It is only to be presumed that there must have been some means of a check in the state treasuries where taxes could be paid in any form, either in coins or in kinds of articles which could be weighed and measured, to be the equivalent of the taxes accruing on them.

But at one place Abul Fazal has mentioned,

> "In order to prevent fraud His Majesty has further commanded that the barley corn shall be made of agate."

This shows that the idea of preserving a standard weight was there. Agate is a very hard stony substance which will not easily wear off.

The balances used and the methods of weighing must have been highly accurate, as is borne out by the fact that the densities of a number of substances determined by them are in very close approximation to the values accepted these days. For instance, the relative weights for the same size of cubes of each kind of metal agree fairly well in their ratios with what we would determine now.

The table given below will illustrate this :

Gold	100
Mercury	71
Lead	59
Silver	54
Iron	40
Copper	45

They called this difference in weights of the same volume of substances, specific difference

They knew how to compare the densities of substances by comparing the masses of cubes of equal sizes as well as by the hydrostatic method of determining the quantity of water that the same mass of different substances would displace. The values for specific gravity calculated from their readings agree fairly well with those accepted in our present time.[3]

It is fascinating to note that though they had such a high degree of accuracy in these measurements, their notions about the constitution of matter were still primitive. This will be evident from the following paragraph.

> "All metals are compounded of vapour and exhalations, which are formed of the four elements; consequently that mixture wherein there are abundance of fire and air, will be comparatively lighter than those which abound with watery and earthy particles. So that cubes of equal sizes of each kind of metal, will differ from one another in weight . . ."

MEASUREMENT OF TIME

Quite from olden times the rhythms of nature have provided standards for time keeping. Abul Fazal has mentioned the motions of the sun and moon and the heart beat as the basis for time unit. And he has also explained a man-made machine for the measure of 'ghurry'.

The day was divided into sixty equal parts called 'ghurry'. Ghurry was divided into sixty equal parts called 'pul', and pul was divided into sixty equal parts called 'narry' or 'bepul'. The narry consisted of six respirations of man of temperate habits in perfect health, while at rest.

ASTRONOMICAL MEASURE

In astronomical calculation the 'ghurry' is different. The breath respired was called 'swas' and that which is inspired 'purswass' and collectively they call it

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[3] Cf. Nigama, U.S. 1954, Note on Densities *Science & Cult.* 19; 610

'puran'. Six purans make one pul and sixty puls make one astronomical ghurry or hour, 24th part of a day and night. Thus one astronomical ghurry is equal to two and a half of the ordinary ghurry described earlier.

At one place he writes,

> "All nations compute time by days and nights. The natural day in Turan and in Europe is computed from noon to noon. In China and Chinese Tartary they reckon it from midnight to midnight, but the generally of peaple reckon from sunset to sunset."

On the same he goes on to state :

> "According to Hindoo philosophers the natural day is thus computed·
>
> In Jumkote, which they make to be the eastern extremity of the globe, from sunrise to sunrise—in Roomak the western extremity, from sunset to sunset --in Lunka the southern extremity from mid-night to mid-night; and in Delhi also they reckon in this manner—in Suddapore, the northern extremity, from noon to noon. The artificial day consists of a complete revolution of the sun round the earth, without making any allowance for its retrograde motion.
>
> "In the astronomical table of Nebatee, the difference between a natural and an artificial day is made to be fifty-nine minutes, eight seconds, eight third and forty six fourths. Here he quotes a number of different tables and the differences found by them and assigns these disagreements to the difference of skill or the defects of instruments.
>
> "The year and the seasons are computed from the sun's revolution round the zodiac. From this quitting one point till his return to the same again is a year. The time that he remains in one sign is called a solar month. The time that the moon takes in going from one conjunction with the sun to another, or from one apposition to another or such like, is called a lunar month."

Let us now look to another view of the 'ghurry' that he has mentioned :

> "The Hindoos say, that a man of temperate habit in full health, respires 360 times in space of 'ghurry' or 21,600 in course of a day and night."

It is significant to note that the respiration time as calculated from their standards is almost the same as we find recognised normally to-day, i.e., 4 seconds.

There is a mention of a number of Eras, some of which must have been prevalent in the different sections of the population creating confusion of dates,

> ". . . . . .His Majesty in the 29th year of his reign ordered that all old dates should be discontinued and a new one substituted in their stead .. "

We again notice here the effort at maintaining uniformity in reckoning years.

Mention is also made of a number of observatories, along with the number of years they had been in existence

Abul Fazal also mentions the use of almanacs called **Putterch** by the Hindoos.

MACHINES AND TECHNOLOGY

It is generally believed that our knowledge in the field of machines and technology was very deficient, and probably rightly so. The following will help us to form an idea of their achievements in this field also.

> The armoury was fairly well developed, and "excepting Room (Rome) no kingdom can compare with this in the number and variety of its ordnance."
>
> "Some pieces of cannon are so large as to carry a ball of 12 maunds; and others require each several elephants and a thousand bullocks for their transportation.
>
> "His Majesty invented 'several kinds'; some of which are so contrived as to be taken to pieces for the convenience of carriage and when the army halts, they are put nicely together again "
>
> 'Bundooks are now made in such a manner that when filled with powder up to the muzzle there is no fear of their bursting. Formerly they never wore more than four fold of iron and sometimes only one jointed together by their two extremities of the breadth, and which were very dangerous. His Majesty after having the iron flattened has it rolled up like a scroll of paper but slantingly, and every fold is passed through the fire. There is also the following method. Solid pieces of iron are properly tempered and then bored with an iron borer; and three or four of these are joined together to form a bundook".

This shows that making barrels by the method of boring was also being done This information is followel by,

> "Formerly it required a great many men with a number of iron tools to polish the bundooks, but His Majesty has invented a wheel which is turned by a single bullock, and polishes sixteen muskets in a very short time."

Speaking of other machines he writes,

> "His Majesty has with great skill constructed a cart, containing a corn mill, which is worked by the motion of the carriage. He has also contrived a carriage of such a magnitude as to contain several apartments, with a hot bath; and it is drawn by a single elephant. This movable bath is extremely useful, and refreshing on a journey.
>
> "He has also invented several hydraulic machines, which are worked by oxen. The pulleys and wheels of some of them are so adjusted, that a single ox will at once draw water out of two wells and at the same time turn a mill-stone."

Akbar must have possessed great inventive genius to have so many mechanical contrivances attributed to him. Perhaps it was his pre-occupation with such thoughts that did not leave him time for learning to read and write, and left him illiterate as the historians call him.

Abul Fazal makes out that the department of navigation flourished well.

> "Every part of the Empire abounds in boats .. . In the maritime provinces ships are built of a size for sea voyages. And also at Allahabad and Lahore ships are built and sent from both places to the ocean".

CHEMISTRY

The science of chemistry seems to have been fairly well advanced. They knew the process of refining gold and silver, and were acquainted with a number of metals, but the author has not made a mention of more than eight or nine metals.

Strangely enough no emphasis is laid on alchemy, though they regarded gold made by the touch of the Paras (Philosopher's Stone) to be that of the best quality, as they thought it would contain no impurity.

They had a number of methods of comparing the purity of gold by the touch stone.

They knew about the extraction of some metals. And they could also identify the ingredients of an alloy. Yet systematic chemical analysis has not figured anywhere in the book.

The King was very fond of scents and hence a number of prescriptions for different kinds of perfumes have been noted by Abul Fazal.

The mention of medicinal shrubs and herbs is comparatively small, though 'Ayurveda' must have been very much in vogue.

Then he passes on to discuss the coinage system of those times and the minting of coins.

In the field of geography he describes the boundaries of 'Jummoodeep' which was Asia.

The discourse on geography includes a discussion on finding latitudes and longitudes, and a table giving latitudes and longitudes of a number of places is also appended in the volume.

Let us now have a glimpse at the natural sciences.

In the field of botany, we find mention of a number of different kinds of wood, a very large number of flowers, their colours and the seasons in which they bloom.

There is also a mention of a variety of indigenous and imported fruits along with the names of places where they came from.

About sandalwood he writes,

> "This tree is a native of China. It has been brought to Hindustan in this reign and thrives very well"

This statement is worth investigation. How and when was it actually brought and in which part of the country was it first planted? Did it or did it not exist in the south of India prior to the reign of Akbar? There is such profuse mention of the use of sandalwood in the early scriptures of the Hindus that it is almost incredible that it was not there prior to the reign of Akbar.

In the field of zoology, he has written at length about animals and birds. Particular attention has been paid to the capture of elephants, their upkeep, etc. This animal was of great use in transporting artillery. A fairly detailed mention has been made of the horse, the mule and the bullock, their upkeep and their bread. He has even made a comparison between foreign and country breeds, the Ketch and the Arab, etc.

In the second volume he writes about birds and beasts of Hindustan and the following passage on p. 400 is rather intriguing.

> "The Bun manus is an animal of the monkey kind. His face has a near resemblance to the human; he has no tail, and walks erect. The skin of his body is black and is slightly covered with hair. One of the animals was brought to His Majesty from Bengal. His actions were very astonishing.'

This statement needs investigation, and verification. The chimpanzee or the ape has so far been supposed to be foreign to our country.

There is a very long chapter on astronomy in the book. This has not been touched in this article, at all, as it was tending to become too long. For the same considerations the subjects of chemistry, geography, botany and zoology could not be given a proper deal. But **Aayeen-e-Akbery** indeed opens a big window to the realms of medieval science.

ON SCIENCE EDUCATION IN SCHOOLS

U. P. BASU

Bengal Immunity Research Institute, Calcutta

Although science teaching had no prominent place, science has always formed an integral part of our education since time immemorial. From the latter part of the 19th century science and with it, technology, have advanced far to increase the power of man, and are gradually expanding the stature of a nation. Today development of modern science means enhancement of the prosperity of the country. It is a problem for us in India how with a per capita income of only Rs. 330/- per annum, we may go ahead with our nation-building programme after feeding millions of hungry mouths. The economy is to be improved and this is possible only by increasing the agricultural and industrial output. This can be done by developing our technology through education in science. In this task the biggest problem would be fixing the pattern of secondary education, and providing qualified and competent teachers in science. Teachers will have to kindle in young aspirants coming from the primary schools the fire of enthusiasm and a desire to receive higher training in science and/or technology at a later stage. A short cut method has lately been adopted by introducing in the 11-year school course a stream of science training. But there must be a band of teachers in the various disciplines of science to train boys and girls in a way that they may meet the increasing requirements of high-skilled specialists for the economic and technical advancement of the country.

PATTERN OF EDUCATION

We are in a dilemma with the different aspects of our problem in educating children in science and technology. Perhaps difficulties are created by the fact that we try to imitate the methods that have been followed in other developed countries. The fundamental object of education is not only to impart knowledge, but also to develop a moral character in order to lead the individual to the perfection of his abilities and powers. It is for this that education should not stop at any stage, but should continue throughout life. If this be so, then the method that prevailed during earlier centuries in our country, namely, the one based on the principle of training through ashrams is the most original. A critical scrutiny would reveal that this principle has been adopted by many nations suitably adjusted to their social and economic conditions.

NEED FOR WELL-TRAINED TEACHERS

Our country is in need of food, cloth, materials for housing, and requisites for maintaining good health. As such science education should be oriented from the very beginning to enrich the boys with the idea of making the country self-sufficient in the above respects. More abundant water, better methods of agriculture, more fertilizers, diversification of crops, better tools for cultivation, requisite electric power, production of goods that are essential for the masses and similar things would demand a training in well-adapted indigenous technology based on scientific principles Unfortunately, however, Indian science tends to be academic. Physicists are absorbed in theoretical interpretations, chemists are engaged in the solution of problems of chemical kinetics or structures, and biologists are dreaming about issues not directly related to our immediate problems. Will scientists and technologists trained in this atmosphere be able to train youngsters in schools to ameliorate the conditions of people with poor resources? The young scientists when in profession have not only to apply the knowledge that they have acquired in the class rooms of their training centres, but also to solve many problems which might not have been included in their curricula. This would need the acquisition of basic knowledge in the course of their study so that the children may be taught by teachers with a deep insight into the subject and the wisdom to tackle a problem.

The present system of education is mostly divorced from the practical aspects of life. Students are taught to learn the printed words of the books; they are not taught how the described information mingles with facts, events, and surroundings. With the above notions they engage themselves in receiving higher training, and are trained in special lines with very little basic conception of any problem. As a result, when they come out and enter into any profession, they find the surroundings uncongenial after the peaceful atmosphere of the training centres. The mental apathy thus accruing prevents application of their ideas and retards interest in the practical field. The country needs students with wide and liberal education. Besides proficiency in scientific knowledge and technological education, they must possess a good knowledge of literature and history specially in relation to the custom, system, tradition and belief that exist in a society. These help in the formation of a sound judgment, and a knowledge of the human mind. For the success of any scientist in profession the above two are essential qualifications In order to foster the above concept in the boys, teachers must be versed in academic knowledge as well as possess a reasonable experience in the practical field. This means, teachers to be recruited must not have only one way of training from school to university stage but be nurtured in a professional field like trade, commerce or industry as well. For this purpose, science experts from different practical fields should be invited to lecture on subjects of their special experience.

METHODS OF TEACHING

The intellectuals of our country are in general agreement that the system of imparting education, particularly in science needs renovation. The bottle-neck, however. lies in procuring adequate funds for improving the current system; but no less an obstacle would be found in an inferiority complex developed under an alien bureaucratic rule. We have lost sight of the advantages of our ancient life; at the same time we have also not been able to assimilate the neo-concept of corporate life that is demanded in a modern industrial society. In the United Kingdom, children develop corporate feeling through congregational instruction and group activities in their schools. It is to be seen whether a religious training imparted collaterally with education on scientific humanism, will give a new enthusiasm to our boys and girls in moulding their habit of work for the good of the common man. The spirit, if acquired, will certainly help them in offering a sustained service to the state, university or industry. For such moulding we need the services of highly enlightened and properly trained teachers. They are, however, to be carefully nurtured in body and mind. There are other factors which must not be lost sight of. Fixation of curricula, the question of language, health and living conditions of the students, methods of judging their merits, offering opportunities for gaining practical experience, and similar problems need careful study, especially, as science is progressing rapidly. It is becoming difficult to acquire the knowledge developed ever since 1900, or be fully acquainted with the developments that have taken place within the last decade. The problem is somewhat complex in India as different social systems may hamper the fixing of a common methodology. Segregation of students varying widely between the limits of intelligence and that again from different zones should be made under careful supervision of expert psychologists and they should be put in schools to be managed by a central authority for training in modern science and technology. The system may help in national integration and also in creating better talents in the country. The teachers are also to be recruited after practical proof of their efficiency in teaching work, method of delivery, patience, mellowness of temper, and knowledge about the cultural trends of the country. Here the question of recruiting women teachers at least for teaching at the lower stage of education also arises. We will then have to think about co-education particularly as we are moving for imparting science education at the school level.

EDUCATION FOR INTEGRATION

The education of any individual is influenced by three factors (a) the attitude of parents, (b) the policy of the Government, and (c) the capabilities of teachers. Many of our parents consider education to be the means of securing better job in life. They do not give any cultural value to science education. Teachers engaged in teaching have not also been trained and nurtured with the concept of developing science for the benefit of human society. Many are yet to be convinced that scientific knowledge can progress only by co-operative ventures and mutual respect for discovered facts. Study of science induces growth of loyal co-operation and a mutual trust and confidence amongst people of divergent disciplines. This is a quality which is absolutely essential for national integration. In no case should education be mixed with politics, and Governmental policy should be specific on this issue. Political control of education is a favourable breeding ground for the philosophy of authority, and in conditions may give rise to evils. Teachers, working as 'gardeners', will then naturally look after their 'plants' according to their own choice and need, but not in the interest of the nation and the society. The object of education is to provide an individual with the best that the country can provide. Here again a distinction exists between science education, and education in classics or literature. It is a fact that the subjectmatter in science and technology is increasing while the time available for study remains the same. On all these counts science education in schools and colleges is becoming intricate, and this is more so in a resurgent country like India.

CONCLUSION

If science is to be developed for the betterment of the people, students must be very carefully trained in the elementary and secondary stage of science education. A critical survey would show that an inadequate practical education is also partly responsible for training students inadequately at the higher level. Mathematical conception should be very clear for those who desire to develop their career in science, and as such, more stress should be laid on mathematics. Further, students must engage themselves in more extra-curricular work. This is nothing new in India, as here in ancient times pupils used to work in diversified fields during their training. As advancement of science will defeat its purpose unless it is transformed into some utilitarian use, a better understanding of human needs is essential. This is to be clearly conceived from the very beginning and the whole school course should be adjusted accordingly, and followed with precision. It is in the school stage that children who are being trained in science, must be infused with a love and respect for the principles of a socialistic society, and then it would be easier for them to become scientists to meet the needs of the country.

USE OF PLASTIC MATERIALS FOR SCIENCE TEACHING

P. S. V. RAO

B.E.M. High School, Mangalore

We are living in an age of plastics. Varieties of articles made from this wonderful material are available and some of them can be used for science teaching. They are comparatively cheaper than glass articles. Besides being transparent they are not as brittle as glass. Further, many apparatus can be improvised out of them without tools

I have used some of them to improvise apparatus suggested by the UNESCO Source Book for Science Teaching and other handbooks for science teachers. I have given below a few of the uses to which I have put these articles

PLASTIC BAGS

Plastic bags are available in assorted sizes. They can be procured without any cost. They can be used in the laboratory for various purposes.

Transpiration: The plastic bags can be used to demonstrate transpiration. Figure 1 shows the method of using these bags. The advantages are obvious.

Storage and display: The plastic bags can also be used to store seeds. Figure 2 shows the method of displaying the stored seeds. The bags may be mounted on plywood discs with drawing pins. They make attractive exhibits.

Coverings: Skeletons of birds and animals can be covered with plastic bags. They prevent dust from settling on the skeletons.

CELLOPHANE

Cellophane strips can be used to show osmosis. A piece of cellophane (from a cigarette packet) is tied tightly across the mouth of a thistle funnel with cotton and the joint is made water-tight with Faraday's cement. (Method of preparing this cement is given on page 195 of the UNESCO Source Book for Science Teaching). Figure 3 shows the method of setting up the experiment.

PLASTIC BOXES

Varieties of boxes in assorted sizes and shapes are available. These boxes can be used for various purposes.

Square Boxes:

These are very useful for displaying crystals. Small crystals are mounted on corks cemented to the base of the boxes. Figure 4 shows the method used. Bigger

Fig. 1

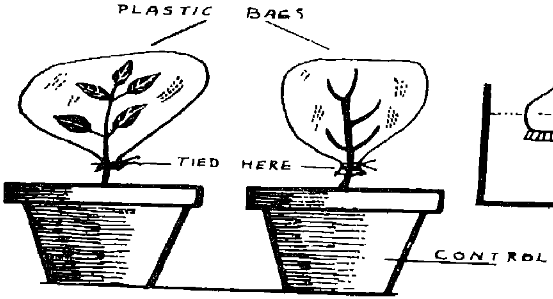
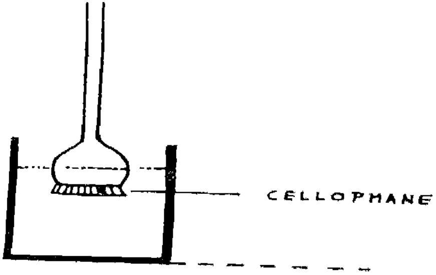


Fig. 3



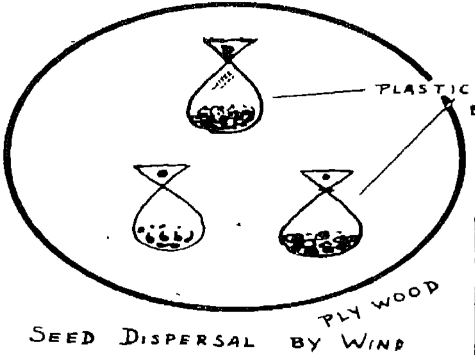


Fig. 2

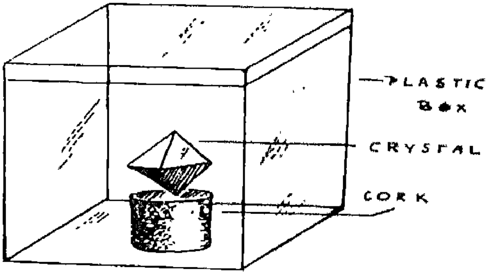


Fig. 4

Fig. 5

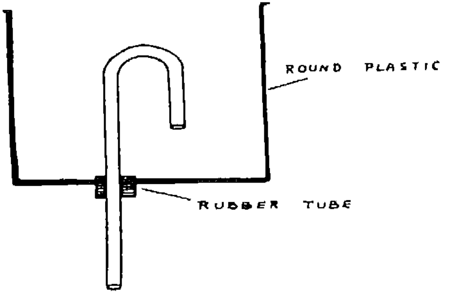
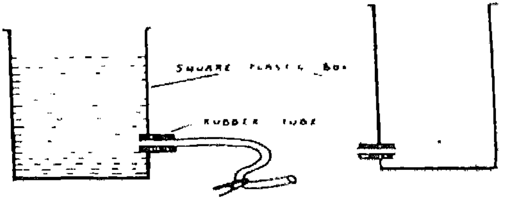


Fig. 7



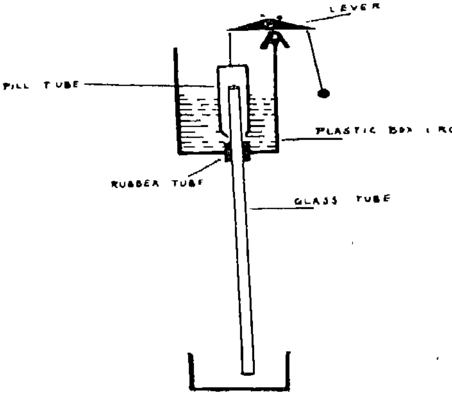


Fig. 6

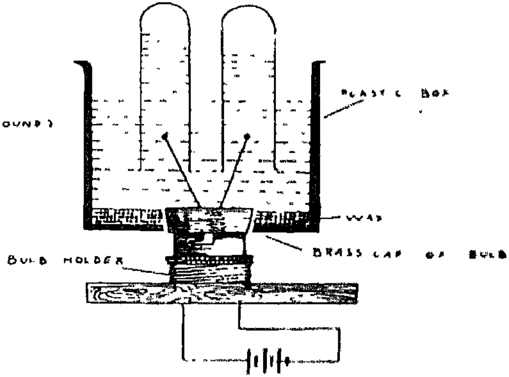


Fig. 8

crystals may be placed in the boxes without a mount. The lids may be sealed. This prevents the unnecessary handling of crystals. Boxes of uniform size make attractive exhibits in the laboratory Square boxes may also be used to display minerals and rocks.

I have used the square boxes to improvise the apparatus to show how water flows in a tube as suggested by the UNESCO Source Book for Science Teaching. Figure 7 shows this apparatus Holes are made and enlarged to the required size by means of a red hot nail. The joints are made watertight by using a piece of pressure rubber tubing slipped over the glass tube as shown in the sketch.

Round Boxes:

These can be used for improvising a large number of apparatus.

Tantalus Cup · The usual apparatus supplied by dealers often leaks at the joint and the cup is also very narrow. Figure 5 shows how to make one using a large plastic box.

Flush Tank. Figure 6 shows the use of a plastic box in improvising a flush tank. The sketch is self-explanatory. The lever is attached to the side of the box with the help of a clothes peg. The string is attached to the pill tube by means of sealing wax.

Voltameter: The School Science Review of June 1958 contains a suggestion for using old light bulbs for lead-in-wires. The piece of old fluorescent tube suggested for making the cup of the voltameter is too narrow. Further, it is difficult to cut the tube. I have prepared a voltameter using a large plastic box for the cup. Figure 8 illustrates the method of preparing the voltameter.

Overflow Can· Large plastic boxes can be used to prepare overflow cans. A hole may be made with a red hot nail in the side of the box. The hole can also be enlarged to the required size. A spout made from a piece of tin is inserted into the hole and cemented with Araldite (cement manufactured by CIBA).

Card Compass: A plastic box may be used to prepare the card compass suggested by the UNESCO Source Book on page 147. The thread carrying the needle may be passed through a hole in the lid and tied to a match stick.

The above items show how some of the plastic articles can be used for making improvised equipment for science teaching. In a country like ours, where schools are poorly equipped, the possibilities of using plastic materials are wide and varied.

BIOLOGY AND SOCIETY

D. SHANKAR NARAYAN
University Grants Commission, New Delhi

The human society is credited to consist of gifted 'social' animals but it seems rather immature and to be so imperfect in its socialisation when compared to the level of social life attained by certain lower animal groups, particularly certain insects like ants, bees, termites, etc. Every individual in the human society seems to crave for social integration with his fellows, yet it would be extremely difficult to persuade him to abate one little of his natural desires and appetites and every individual would resist to the utmost any profound specialisation such as would be demanded by the principle of the division of labour in any perfect society. The social problems of human society may be quite insoluble and complicated but it could do much better than at present, if it solved the three fundamental problems of nutrition, reproduction and social defence in much the same way the termite society did nearly 50 million years ago, the latter society founded on sound biological principles.

The great majority of insects are solitary in their mode of life, each living for itself except at mating time. Beyond placing the eggs or their offspring, either by instinct or design, the parents usually take no interest in their offspring. The parents usually die before their progeny mature and consequently there is no opportunity for parent-offspring relationship.

However, there are certain other groups of insects whose species have a social mode of life In the termites, ants and social wasps, social life is well developed and complex, embracing almost all phases of individual activities. Other insects show interesting tendencies through such phenomenon as maternal care, social larvae and community development.

Among insect societies, the female insect occupies the most dominant position, she being the foundation, the perpetuation and the multiplication of species. The history of development of 'white-ant' or termite society, as narrated by William Morton Wheeler's, neotenic King of the Dynasty of the Bellicose termites is vividly illustrative of the biological considerations on which that society was founded and has flourished through millions of years.

According to tradition the ancestors of the present-day termites descended in early cretaceous times from certain kind-hearted old cockroaches that lived in logs and fed on rotten wood and mud. Their progeny, the aboriginal termites, although initially confined to this unpromising diet made two important discoveries. First, they chanced to pick up an assortment of Protozoa and Bacteria and adopted them as an intestinal fauna and flora because they were able to render rotten wood and mud more easily digestible. The second discovery, quite incidental but more important, was nothing less than society.

Perhaps, the termites at first allowed their offspring to drift but soon found out that the fatty dermal secretions or exudates of the young were delicious food and that parents could reciprocate with similar exudates as well as with regurgitated, predigested cellulose. This marked the beginning of family life, for an elaborate exchange of such exudates, the 'social hormones' which continually circulating through the community bound all individuals in one syntropic unit, satisfied to make digestion of wood a serious occupation and swapping of each other's exudates a delight of leisure moments. Thus it is said that this society arose from a co-operative mutualism of symbiosis. These individuals did not start a society because of the platonic thought of loving one another but they loved one another because they were so sweet. The society supervened as a necessary and unforseen by-product.

Such a society embarked on its career with most brilliant prospects because the world was full of rotten wood and mud and no laws interfered with distilling and imbibing social hormones But the very comfortable situations they enjoyed made them strike a snag in the mid-cretaceous era. Not only had all the members of society begun to reproduce in the wildest and most unregulated manner but their behaviour toward one another started deteriorating and all undesirable elements such as profiteers, grafters, criminals, morons, feeble-minded, idiots and insane began to fill the society. The few sane termites were thinking of returning to solitary life. But the situation was saved by a royal termite who introduced such reforms as to lead the termite society back to its glory as a most highly integrated social organisation.

This termite had the happy thought to refer the problems of social reform to biologists, who were, of course, few and busy with their own in some remote corner of the termitarium These biologists were rounded up to meet in a series of conferences for purposes of stridulating about the relation of biology to society. After several million meetings they adopted a splendid programme for the regeneration of termite society

These biological reformers started with the presumption that a termite society will not survive unless it is constructed on the plan of a super-organism subject to certain fundamental laws normally applicable to an individual organism. Its success will have to depend on the solution of the three basic problems of nutrition, reproduction and protection and these problems cannot not be solved without a physiological division of labour among individuals of the society the sowing of seeds of classes or castes. Thus the termite society became divided into three distinct castes according to the three organisational needs and functions, the workers being primarily nutritive, the soldiers defensive and the royal couple reproductive. Unlike in ants, these societies remained bisexual, there being both male and female workers and soldiers These two castes were forbidden to grow wings or reproduce and the royal couple were relieved from all the labour of securing food and defending the termitarium in order to devote all their energies to reproduction. The carrying out of this reform resulted in automatic regulation of the size of the population to correspond with food supply and facilitating production of perfect offspring—mark the beginnings of family planning.

The practical geneticists among them took over at this point and made two important contributions. (1) The plant breeders found it useful to convert the communited wood remains into spongelike structures and utilised them for growing mushrooms, selected carefully for their vitamins to promote growth of reproductive cells. For the latter reason, only the royal caste and the young of other castes were permitted to feed on this mushroom food. (2) The animal breeders brought in adoption a number of beetles and flies and cared for them till they developed exudate organs—thereby converting them into 'cattle' whose exudates served as 'milk'.

While these reforms were in progress, the anarchist elements of the late cretaceous period revolted against the reformers but by Eocene tertiary era the society had developed strict measures of dealing with any termite that departed from the standards of the most perfect social behaviour. The culprit was generally dismembered and devoured by his fellows. Rigid 'eugenics' by confining reproduction to a special caste, rigid enforcement of regulations requiring all anti-social, diseased and superannuated individuals to be promptly disposed of, resulted in perfect ethics and hygiene by the midcretaceous period. The problem of social protection was left to an army of coolheaded courageous soldiers to be employed not in waging war but solely for defensive purposes and building fortifications.

The most gloriously physogastric royal consort is kept busy with oviposition, laying an egg every three minutes for almost four to five years continuously and producing as many as 2,50,000 individuals, all perfectly born and each performing its respective duties, obeying the regulations and dedicated to the success of the super-organism—the termite society. His royal highness is carefully fed, has all the leisure in the world and broods in the royal chamber kept perfectly air conditioned and noise proof save for the dropping of her majesty's eggs and the soft foot falls of the workers carrying away the germs of future populations to the royal nurseries.

At certain times of the year swarms of winged sexual forms issue from the old colonies and disperse. After their flight, these forms alight and wings fall off. Males and females pair off and together begin a small excursion for a new nest At this stage, the mating occurs and later the female deposits and watches over her first brood of eggs. She feeds the first young with saliva and other secretions. Thus a new colony is founded. Soon after hatching the nymphs are self-reliant and feed themselves and parents also. From this time on, the original male and female, called the royal pair, perform only the function of reproduction. In the early stages of colony, provision is made for having a substitute reproductive caste that may become fertile and replace the royal pair if the latter die. The termites have thus provided for emergent situations as well.

This society has remained in such perfect stage since the beginning of Eocene, for the past 50 million years or so mainly for the reason that this society was founded on sound biological principles.

[Source. W M WHEELER (1865-1937)· Paper read at the Symposium of the American Society of Naturalists, Princeton, Dec. 30, 1919 and first published in the *Scientific Monthly*, Feb. 1920]

ARE YOU TEACHING IN THE 20TH CENTURY?

RICHARD MAYO-SMITH JR.
Literacy House, Lucknow

On the wall at the entrance of a teacher training institute in India stands a large blackboard. On this board is written a long list of the qualities of a good teacher. It is an awesome list. In this article I would like to suggest a much briefer criterion but a very testing one nonetheless. It is simply this: How often in your science classes do you say, "That is a good question. I do not know the answer. How can we find out?"

HOW FAST DOES SCIENTIFIC INFORMATION GROW?

Science is the name given both to a group of methods for accumulating knowledge and to the knowledge accumulated by these methods. An outstanding characteristic of science, particularly apparent in recent years, is the increasing rate at which scientific knowledge accumulates. This can be stated in different ways, but perhaps the easiest is to say that the amount of significant information is doubling every ten years. The amount of knowledge available now is twice that of 1952, four times that of 1942 and eight times that of 1932.

Pause a moment and consider what this statement really means: The amount of significant information in science is doubling every ten years. What has this meant in your lifetime? Rocket travel in space, hydrogen bombs, antibiotics, television a whole host of changes beyond the vision of most who were alive in 1910.

And what will the next decades bring? One thing is certain; they will bring changes greater than any you can imagine. Let me give you just one example. What do you think a library of the future will be like? Here is the best guess of the American Library Association. Using a technique known as photochromic micro-image, books will be reduced to a size 1/40,000th of the original. A 400-page book will be reduced to fit a single card the size of a postage stamp, and yet this miniature book will be read easily through a simple projection method. Each microfilmed 'book' can be produced for less than a rupee, so library users of the future will often be permitted to keep the books they withdraw to add to their personal card-file libraries.

This is a glimpse at libraries as experts imagine them to be in the future. Specialists in other fields can predict changes just as startling. In brief, while you and your students are studying science in school, scientists the world around are producing an avalanche of new information to sweep you off your feet. How will you meet this force?

Science is ever changing

At this point a traditionalist might reply that the best solution is to give students the same basic training they have always received. After this solid foundation, they will be able to assimulate the recent changes. Such a reply does not recognize science as a growing, changing body of knowledge. For instance, at one point in the history of biology, it was essential for scientists in this field to concentrate on gross anatomy and classification. But now biologists have passed far beyond this stage and have constructed a whole set of new concepts to explain what is visible to the eye. Just as atoms and molecules were developed as concepts in physics and chemistry, so has the gene, the 'unit' of heredity, been developed in biology to explain the structure, function and evolution of the living world around us. Truths in science are subject to test, and some truths are prominent at one period of a science's growth because they are particularly useful then. Later they may recede into the background. Other truths are modified and still others are discovered to be quite wrong. If science is ever-changing, science courses must be ever-changing too.

But even with the best will and intelligence in the world, can you hope to keep up with all the changes and to include them in introductory courses? Obviously not! Furthermore, there remains the even more impossible task of foretelling what new significant developments will take place in the future and equipping your students to meet these.

No, you can no longer be expected to step into a class room and to know 'all the answers'. As media of communication increase in India, more and more of your students will have greater knowledge than you do about some special section of science of particular interest to them. One will know the thrust of the latest rocket sent to Venus. You may not. Another will have read a special report on recent studies in cancer. You may have missed it. And so it will go.

Develop skills and judgment

In this situation what is a reasonable course of action? You are responsible for teaching your students some information. What information should you select and how should you teach it?

As an active teacher you will be dealing with students and you will be aware of their interests and capabilities. At the same time you will follow some of the major new developments in your field. Thus you will be in a position to contribute helpful advice to those planning curricula for the schools. If they persist in ignoring your voice, you and other teachers like you must group together to put pressure on the planners to listen to you. Indeed this very journal offers you an opportunity to do just this.

But what will you do in your classroom? How will you and your students tame this avalanche of information? I believe you must concentrate on developing skills of analysis and a sense of judgment. Guiding students as they acquire these skills and this judgment will be your function, and herein your age and experience will be of great value to them.

To do this you can no longer control the flow of information as a dictator. You cannot step into the classroom, execute a demonstration and then ask all the questions—questions to which you know all the answers. Listen to the questions in your class. What kinds are they? "Did you say carbon monoxide or carbon dioxide, sir?" "Do we have to know how much sulphuric acid was added, sir?" "When is this assignment due?" Ask yourself: Why were these questions asked?

Encourage student questions

In a 20th century science class the teacher should encourage students to ask questions that have developed from their own observations and interests. At lower levels it may be quite a simple question such as "What is a bug?" or "What happens when something burns?" As the students grow older their questions will become more sophisticated. "What purpose (or purposes) does the cocoon serve in the *metamorphosis of a moth?*" "Does it keep the pupa from drying out?" "Does it protect it from physical injury?' "Does it protect the pupa from light?" "Does it stimulate the secretion of some growth-regulating substance?" Or another set of questions about ants: "Why do the small ants found inside houses follow certain pathways up and down a wall?" "Are the pathways established by odour?" "Do certain scouts establish the pathways for others?" "How stubbornly are pathways maintained in the face of disasters?"

These are questions that show an active and imaginative mind at work, and a teacher who encourages these kinds of questions stimulates his students' minds to grow

What abilities should you possess?

"That is a good question. I do not know the answer. How can we find out?" Each sentence in this quotation requires a different ability in the teacher. "That is a good question" requires you to be able to tell a good question when you hear one. Does the question spring from the student's interest or is it contrived to gain your approval? Does the question relate facts in a new way not presented in class?

"I do not know the answer". This statement shows you have not confined school work to a narrow body of material. Instead you have encouraged students to consider what goes on in the classroom as part of the world outside and to use their training in thinking about this outside world.

At this point you may question the emphasis on not knowing the answer to questions. Ignorance appears to be an attribute of a good teacher. Not at all! There is no rule saying you must not know the answer to a question. The point is that you encourage exploration beyond your own knowledge. (In passing, it is worth noting, however, that one of the most successful science teachers I have known always tried to answer a question with another question rather than give an answer).

Indeed unless you have a good knowledge of your field you will not be able to do your part when you ask "How can we find out?" Students will have little idea of the resources available and they will need guidance in investigating their problem. How you advise him will make a difference in the development of their analytical skills and in their understanding of what science is all about.

Too often in the past teachers of the young, particularly at the secondary level, have been judged by their detailed knowledge of a field. But teaching at its best is not a demonstration of what the teacher knows; it is an effort to stimulate students to grow. A good test for how well you are succeeding in this challenge is the nature of the questions your students ask.

NEW WORLD FOR SCIENCE STUDENTS*

JOHN PFEIFFER

Schools which give play to the natural curiosity of boys and girls are meeting with success in the United States. In a typical class period, the pupils do not sit passively in their seats while an instructor lectures. Nor do they watch from a distance as he manipulates various experiments. Instead, they gather around him asking questions, arguing points, and actually helping with the experiments.

PURPOSE OF SCIENCE COURSES

Courses in the sciences, for example, are designed for boys and girls who will not become professional scientists. The purpose is to give students of high (secondary) school age and younger a feeling for the values and uses of the scientific attitude--not primarily to teach facts. If a child knows what questions to ask and how to find the relevant facts, he can learn what he wants. The teacher's task is to instill the desire to learn, to preserve his students' natural curiousity, so that they keep on asking questions throughout their lives.

Courses of this kind are established in the majority of the 26,000 public and more than 2,000 private high (secondary) schools in the United States. These schools include more than 10,000,000 children, and eight out of ten study general science. Thirty years ago, less than half as many pupils received training in science. But the important difference is more than a matter of large numbers: it is the result of a new philosophy of teaching.

THE OLDER APPROACH

The theory used to be that the mind is a collection of 'faculties' such as memory, observation, concentration, and so on, which could be developed like muscles. Under this method, the students would take notes while the teacher lectured about the subject. At the end of the hour he assigned specified pages in the regular text book and announced a 'recitation' for the following day. Students would be expected to show they had learned their lessons by repeating what they had read.

THE NEW METHOD

As a typical illustration of the newer method of teaching, an instructor prepared for his class by placing a large piece of ice in a beaker and filling it completely half-way-between experiments and play. Other books in the same series take children from the first through the eighth grades.

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* Reproduced from *Amerika* No. 50.

The fundamental aims of this progress are stated in a book prepared by the National Association of Science Teachers for the United Nations. 'Science and technology are conditioning the very basis of our life,' the introduction stated, 'and education is accepting the subject matter and the method of science, both broadly conceived. Many scientists and educators believe that a better understanding of the part that science is playing in the world is an essential basis for a study of social problems. While greater problems is not always a guarantee of desired conduct, one cannot deny that it is essential for intelligent behaviour in a democracy',

NEW DEAL IN SCIENCE EDUCATION*

AN AUSTRALIAN EXPERIMENT

An important series of publications used at Sydney University's Summer Schools has been described as 'a shot in the arm of jaded science teachers'.

Writing in **The Australian Scientist**, Professor H. Messel, Head of the School of Physics and Director of the Nuclear Research Foundation at Sydney University, says, that the Sydney Summer Schools for Science Teachers, which began in 1958, have now achieved world-wide acknowledgment as a unique experiment to make the Australian community science conscious and to step up the output of science graduates

Australian complacency was shaken by facts presented in the 1957 Murray Report on Australian Universities. Although Australia's continued development and rising standard of living depends on scientific method and advanced technology the Murray Report showed that too few boys and girls were turning towards pure and applied science in the choice of their careers.

One of the first institutions in Australia to take up the challenge of the 1957 Murray Report was the School of Physics of Sydney University with the co-operation and support of the Nuclear Research Foundation with the University.

Within four months of the publication of the report the Foundation acted: It sponsored the School of Physics' first Summer School for Science Teachers.

As head of the School of Physics and Director of the Foundation, Professor Messel first planned the Summer School as "an experiment in scientific education" This 'experiment' has now become an annual event and has earned a high reputation throughout Australia as well as overseas.

From the beginning, the Foundation decided as a matter of policy to invite to the Summer School only top-ranking scientists in their different fields, even if this meant flying them to Australia for the occasion. The idea was to inspire science teachers who attended the course and thus stimulate them to inspire their students to follow science as a dedicated profession.

The first Summer School, held from January 13 to 25, 1958, was attended by 123 science teachers --101 from Departmental and private schools in N.S.W., 12 from Interstate schools, and 10 from the Services or Educational Administration. But the Summer School was a school with a difference: Instead of the science teachers paying to be able to attend, the Foundation paid expenses to science teachers attending and backed the project to the extent of £13,000.

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* Contributed by the Australian High Commission, New Delhi.

In addition, since only a small percentage of all N.S.W., science teachers could be admitted to the Summer School, its lectures were printed in book form and made available free of charge to each science teacher in the State.

Both practices have been kept up and are now important features of the Summer Schools: Each science teacher attending the schools is paid an amount to help him defray expenses, and each science teacher attending receives the lectures combined in a book, as does every other science teacher in N.S.W. Also, an additional 900 copies of the book are presented to high-schools throughout Australia. Thus a total of 3,000 free copies of each Summer School book are distributed.

Following the resounding success of the first Summer School the Foundation decided to run annual Summer Schools in two-year cycles. Thus each group of science teachers is given the opportunity of attending two years in succession. The first-year Summer School is concerned with bringing science teachers up to date with the latest scientific developments, and the second is more concerned with courses on subjects directly related to the Leaving Certificate syllabus.

The success of the first Summer School, the cost of which was entirely borne by the Nuclear Research Foundation, led to surprising industrial and public interest, and already from the second Summer School onwards companies and individuals came forward as sponsors. The most consistent of these has been Ampol Petroleum Limited which has part-sponsored the 1958, 1960 and 1961 Summer Schools, Consolidated Press shared with Ampol the £10,000 sponsorship of the 1959 school. Philips Electrical Industries Pty. Ltd. part-sponsored the 1960 and 61 Schools, and W.D. and H.O (Aust.) Limited part-sponsored the 1960 School. The 1961 School, the cost of which exceeded £15,000, also had two individual philanthropists as sponsors—Dr. Adolph Basser and Mr. H. G. Palmer - who each contributed £3,500.

WIDE SUPPORT

However, public support for the Summer Schools has not only been confined to financial sponsorship. Far from it. Much to the surprise of the organisers wider and wider sections of the press and general public showed increasing interest, and newspapers, particularly in Sydney, published more and more reports of the lectures. This general enthusiasm culminated in 1960 when one of Sydney's commercial television station, TNC Channel 9, applied for and was granted permission to televise lectures of the third Summer School for science Teachers held last January 11 to 22.

This Summer School, organised by Professor S. T. Butler, Professor of Theoretical Physics in our School of Physics, in collaboration with myself, consisted of 27 lectures under the general heading "from Nucleus to Universe". It was designed to keep science teachers up to date with the results obtained during the International Geophysical Year by means of artificial satellites and other modern techniques, and in general to keep them abreast of the modern "space age". Two distinguished overseas guests were specially flown to Sydney to give five lectures each: Professor G. Gamow (of "Mr Tomkins and the Atom" fame), of the University of Colorado, and Thomas Gold, co-author of one of the major theories on the origin of the universe, of Harvard University. In addition, Professor Bart J. Bok, of the Australian National University, came from Canberra to give three lectures on the observational basis for stellar evolution.

Public reaction was unprecedented and Australian TV audiences temporarily turned these scientists into veritable "TV stars". "Live" telecasts of their lectures and many of the other ten lecturers at this Summer School proved so inadequate and there was such public demand for more that TNC Channel 9 recorded ten of the 27 lectures on video tape and even long after the termination of the School was rescreening them not only in New South Wales but, by arrangement with other stations, also interstate

But there was yet another surprise in store. While the two books containing the lectures of the two Summer Schools were well received by all concerned, there was an upsurge in interest in the third Summer School book, "From Nucleus to Universe". Not only did the Australian general public purchase a greater number of copies from bookshops than before, but overseas companies applied for permission to republish the book in Britain.

"This book is more than a shot in the arm for the jaded science teacher whose equipment is a little obsolete", said leading British science writer G. R. Noakes in his review (*Nature*, June 4, 1960, p 748). "It embodies the new outlook, or the resurgence, of a science that is still an adventure of the human spirit, rather than a mere handmaid of technology. If we are to begin to think seriously, as we shall surely have to, about science as a liberal study in schools, this is the kind of book that will direct our thoughts along the right lines."

OVERSEAS INTEREST

But this was not the first time that a Summer School book had aroused overseas interest. The very first Summer School book "Selected Lectures in Modern Physics"—was republished last year by Macmillan & Co. Ltd. and favourably reviewed by J. M. Valentine in the Bulletin of the British Institute of Physics. "Written for the non-specialist", said the reviewer, "the lectures contain a surprising amount of solid information. Even the most out-of-date science teacher will have a fairly good idea of how the nuclear physicist looks at this world. ."

Together with this book on the first Summer School the Nuclear Research Foundation also distributed to science teachers and high-schools "The Astronomer's Universe", a book by Professor Bart J. Bok, Professor of Astronomy, Australian National University, and Director of the Mount Stromlo Observatory, [illegible] Professor Bok's lectures given at the 1958 Summer School.

The following year the Foundation again produced two Summer School books, "Lecture Notes on an Introductory Course in Modern Physics" [illegible] of lectures to the Summer School, and "Nuclear Power and Radioisotopes" [illegible] on a course of lectures given to the School by Dr. A. I. H[illegible]

HERE TO STAY

The reception these books received and the [illegible] leaves little doubt that the Nuclear Research Foundation Schools for Science Teachers— which, incidentally, are all organised with the co-operation of the N.S.W. Department of Education and the Science Teachers' Association of N.S.W. —are here to stay in one form or another.

This year, again, many of the 26 lectures of the fourth Summer School were televised by TNC Channel 9, and arrangements were made [illegible] some of the telecasts with National (A.B.C.) television channels.

The programme of lectures included a basic series on elementary atomic and nuclear physics including an introduction to the theory of relativity. A distinguished overseas guest, Professor E. E. Salpeter of Cornell University, U.S.A., discussed in a series of 3 lectures the elements of quantum theory and its application to the theory of nuclear reactions and of the evolution of stars [illegible]. Professor P. T. Fink, former Reader in Aeronautical Engineering at the University of Sydney and now Professor of Mechanical Engineering there, presented a series of 3 lectures on aeronautics, rocketry and space travel problems.

In addition, Professor C.B.A. McCusker discussed high energy nuclear physics and fundamental particles (3 lectures). Dr. E.G. Bowen of C.S.I.R.O., Melbourne, discussed selected topics in solid state physics (3 lectures).

The lectures were all combined into two books entitled "Space and the Atom" and, 'A Modern Introduction to Physics' Vol. 3.

THE WONDERS OF MICROCALORIMETRY

FERNAND LOT

CALORIMETRY is a difficult world for the layman. However, we should remember these words of Charles-Edouard Guillaume, a Nobel Prize winner and famous inventor of the precious alloy invar, who said: "Metrology which is considered the driest of sciences opens on poetry!" This even applies to the look of Professor Edouard Calvet, who presides over the Marseilles university laboratory of General Chemistry and who developed microcalorimetry which we shall discuss briefly. Microcalorimetry is that branch of physics which tries to measure the quantities of heat in various phenomena in which heat is important. Professor Calvet advances in this science like an explorer before whom unsuspected horizons open He does not hesitate to show us the chase to which he invites us -a chase into the unknown after infinite fractions of calories since, in this field, he attempts to find the 'least' which is available in order to obtain information on the most unexpected.

The beginning of Professor Calvet's research on calorimetry was the research made by his teacher Albert Tian, to whom he continually pays homage with zeal which scientists maintain for those who have opened the way into a new field.

Professor Calvet was his disciple along with Mrs Calvet, both of whom have the degree of 'Agrege' in physics. Mrs Calvet perfected the first calorimeters made by Albert Tian and subsequently remarkably improved. During the occupation, when women and children were sent to the country, Mr. Calvet worked with the botanist Henri Prat, who is now director of the Institute of Biology of Montreal. One day, an idea came to them · If one could make a grain of wheat sprout in a calorimeter, one could study the thermogenesis of germination.

This was the beginning of admirable experiments.

The two research specialists succeeded in recording a curve which was very significant: a curve which was a graphic sign of the flow of heat with regard to time and which was proof of the rising life of the grain. They varied conditions, successively using alcoholized and chloroformed grains, and catalizers capable of accelerating the process. The precision of the recordings made by this microcalorimetric method was such that even today the question is still the object of extremely important research in Canada where the reign of snow begins in September and lasts until May, which gives the problem of accelerated germination a capital interest. Mr. Obolensky, of the Alberta Laboratory, discovered that acceleration could be favoured

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By courtesy from the French Embassy, New Delhi.

by treating the grains with ultrasounds. In some [illegible] the microcalorimeter, tell if such a grain thus treated [illegible] of a month in Marseilles, Mr. Obolensky was able to [illegible] results obtained in a record time.

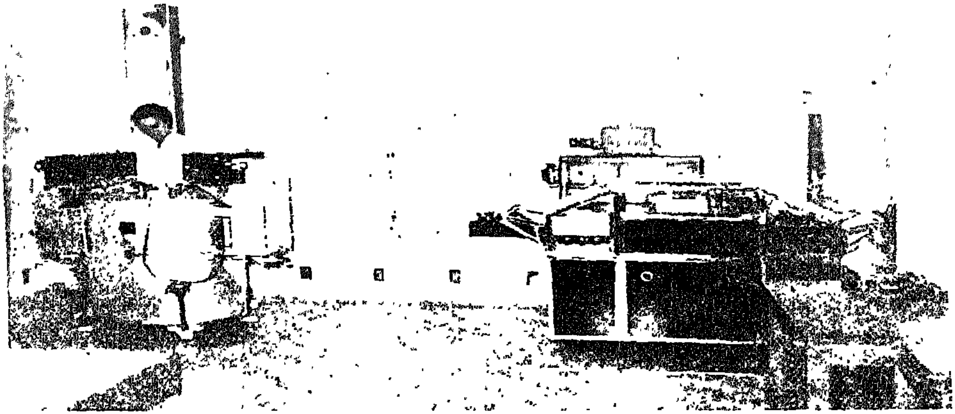
A new *field of investigation has been opened in* the [illegible] now possible to record a curve of thermogenesis when [illegible] vated in a broth. The curve is so specific that it [illegible] example, the culture is a typhus bacillus or a paratyphus bacillus [illegible] produced during the microbial development is not the same [illegible] for all cultures. And without chemical intervention, one can study the [illegible] antibiotics on the development of microbes since, when development [illegible] tion of heat ceases soon thereafter. Inversely, one can study the [illegible] means of microbial development and then obtain a real [illegible] which it surrounds.

Moreover, microcalorimetry provides a new means of analysis [illegible] such as the hydrolysis of amides and esters. With it the [illegible] already found a decisive method for perfecting the production of [illegible] the present, it was necessary to use huge quantities of crystalline [illegible] alumina from original bauxite attacked by soda. Professor Calvet [illegible] establish that it is the amorphous part of the products used and not, [illegible] thought, their crystalline parts which determine the desired crystallization. It [illegible] be noted that during this research, the observance, on recorded curves, [illegible] anomaly was enough for the experiments, sensitive to the fact that the microcalorimeter is not infallible to discover a new element, soda [illegible]

In addition, all the complex science of high polymers, which depends on the industrial multiplication of plastic materials, can benefit considerably from the investigations allowed by microcalorimetry, which explains the presence of the Calvet device in the laboratories of the Saint Gobain Company at Croix-de-Berny. Similar devices are found in many plants especially at Pechiney in Aubervilliers. Those in Canada at Montreal and Ottawa are devoted to research on the selection of seeds and spring planting tests.

But what does this precious device look like? If we enter what is the sanctuary of the Marseilles Laboratory of Professor Calvet, we find ourselves in a room whose *constant temperature of 20° is maintained by a vigilant eletronic brain and where* the air is continually filtered from the ceiling through 54 openings and taken out through other openings found in the floor.

A microcalorimeter is held in an enormous block of copper weighing 100 kilos (the form of which necessitated long detailed studies), covered with an aluminum envelope. In the heart of this enclosure, which acts as an excellent thermostat, are found two small silver cartridges isolating mica sheets, each of which has tiny solders of thermocouples formed of *iron and constantan.*



Microcalorimeter

The layman is tempted to marvel at the extraordinary sensitiveness of the microcalorimeter, which is miraculously capable of showing a trace of heat freed by a single grain of germinating wheat. The sensitiveness is only that, well known to physicists, of thermocouple, capable of producing an electric current at the least heating of the solders in their circuit. For one degree of difference in temperature between the solders, a thermocouple provides a potential difference of 30 microvolts. If 200 of them are assembled it is possible to measure a millionth of a degree. But the best thermostats have been able to measure a thousandth of a degree. Because of the invention of a subtle differential system, because of a device eliminating all electrical parasitical forces, because of thermal lenses delicately calculated to correct the effect of the slightest disturbance coming from the exterior, and because of a radioactive element included in a micro-tube and freeing in a given time a quantity of measured heat, the microcalorimeter, which is perfectly stable at zero, can faithfully measure temperature variations of a millionth of a degree and heat flows of approximately one microwatt. The possibilities which this device offers are many and the microcalorimeter functioning at low and high temperatures will further increase the range and scope of action of this device.

BOOKS FOR YOUR SCIENCE LIBRARY

[The science of Biology has undergone incredible changes during the last half century. Research, new discoveries and new approaches have imparted to the subject a rapidly changing character. Every new discovery does not merely add to our knowledge, but it also compels us to re-appraise and even to change the foundations upon which biology rests. It is, therefore, necessary to introduce Biology to students as a dynamically growing science. It is equally necessary to see that the teacher of Biology enjoys enough freedom and flexibility to adapt the level and structure of his course. The *Foundations of Modern Biology Series* represents the translation of this need into a set of short, inexpensive, well written and well-illustrated books. There are eleven books in the series. The Cell, Cellular Physiology and Biochemistry, Heredity, Adaptation, Animal Growth and Development, Animal Physiology, Animal Diversity, Animal Behaviour, The Life of Green Plants, The Plant Kingdom, and Man in Nature.

Each little volume is complete in itself and at the same time links up with the rest of the series. In this issue we introduce the reader to five of these books.

Editor]

Heredity: DAVID M. BONNER.

Foundations of Modern Biology Series.

Prentice-Hall Inc. New Jersey, U.S.A., pp. i – xiv + 112, 1961.

The discovery of Mendel's Laws of inheritance leading to the development of the science of genetics is one of the greatest scientific achievements of this century. All organisms, plants or animal, mouse or man, and bacteria or virus, follow the same laws of heredity propounded by Gregor Mendel over a century ago. This shows the unity of life and the ability of protoplasm to manifest itself in innumerable forms. The recognition of the self-replicating gene as the elementary basis of life, and the knowledge that the genes are located on bodies called chromosomes and that the number of chromosomes is characteristic of a given species have helped in understanding all deviations in evolutionary and developmental patterns.

It is high time that our young boys and girls learnt that chromosomes, and not radium and uranium, are the most precious materials in the world. Seen in this light, the book under review fully lives up to the aims of the Publishers in initiating the "Foundations of Modern Biology Series" of books.

Prof. Bonner has treated in a lucid way the many complex phenomena associated with the structure and function of genes. He shows clearly why we consider that the genetic information is coded in the chemical substance deoxyribonucleic acid (DNA) of the chromosomes and what role other substances play in translating the information into action. The chapter on 'Genes and Man' though brief, is adequate to underline the need for imparting a sound training in genetics to our biology and medical students. When this is done, many prejudices based on skin colour and other morphological traits as well as many incorrect social beliefs would vanish. Thus, men who blame their wives for not bearing sons would find out that, if any one should bear a grudge it is the wife and not the husband, since it is the father who determines the sex of the child! The harmful effects of many other social practices such as those leading to inbreeding would also become widely known if all our students learn the elements of genetics. This would provide a sound basis for building up an integrated nation of strong, vigorous and healthy individuals.

The last chapter of the book entitled 'Heredity and Hiroshima' is of great topical interest in view of the increase currently being brought about in atmospheric radioactivity through nuclear detonations. Prof Bonner rightly stressed that increased radiation represents a serious human hazard and that the threat to human life posed by radioactive fallout is a new cycle of nature, a twentieth century cycle, created by man. The implications of the genetical knowledge that we now posses are thus clear. We can use this knowledge for the betterment of man as well as the animals and plants upon which we are dependent. We can also use this knowledge to restrain ourselves from embarking upon disastrous adventures involving nuclear warfare, since these will affect not only our generation but many generations as yet unborn.

The book is very well written and the illustrations are both apt and excellent It is a must for all teachers of biology.

M. S. SWAMINATHAN.

The Plant Kingdom: HAROLD C. BOLD.

Foundation of Modern Biology Series.

Prentice-Hall Inc., New Jersey, U.S.A., pp. i—xiii + 114, 1960.

The science of biology is advancing so rapidly that new discoveries are made and new facts emerge which compel us to change or modify our existing views on various topics. No textbook on the science can remain long without being revised in the light of new facts. There is not a single textbook in botany at the graduate level which is so comprehensive as to include all the areas of study within the subject. The needs of the student and teacher are best met by a series of well-written short books, each dealing with one particular branch. *The Plant Kingdom* is one such in a series of eleven books published under the Foundation of Modern Biology Series.

The author is a well-known authority in the field of plant morphology. In this booklet the author surveys the diversity of the different plant groups emphasising the biological principles illustrated by them.

The book is divided into ten chapters including the introduction in which is given a table of summary of some classification of the Plant Kingdom. The author has included his own system where new names are used for the different taxa which have not become familiar, nor as yet accepted by botanists. This is particularly the case among the groups of fungi. The term Tracheophyta of Tippo is abandoned altogether. The succeeding chapters deal with algae, bacteria and fungi, mosses and liverworts, structure of vascular plants, vascular cryptogams, gymnosperms, angiosperms, and a summary.

Each chapter gives an insight into the plants of the group, their biological and economic importance and the broad features of the morphology of the plant body and their life histories. No attempt is made to deal with types separately.

The last chapter is a summary dealing with the organisation of the plant body, reproduction, and development of plants in time. A list of a few books for selected reading and an index are given at the end.

The book is well got up and the layout is attractive. The photomicrographs are well reproduced bringing out details of structure. Though small, the book has a wealth of facts stated in precise language. It will be useful to all students of biology whether in a college or a high school.

S. DORAISWAMI

Animal Diversity: EARL D. HANSEN.

Foundation of Modern Biology Series.

Prentice-Hall Inc., New Jersey, U.S.A., pp. i–xii + 116, 1961.

Biology after remaining for a long time a predominantly observational and descriptive discipline has recently changed largely into an experimental science. The significance of this change has not often been realized in our country. This admirable Prentice Hall series entitled "The Foundation of Modern Biology" presents the dynamic state of modern biology and will be of great help for our teacher to determine his approach towards the subject.

The seventh volume of the series deals with animal diversity. The author has successfully employed the scientific method to increase our understanding of animals and the reason for their diversity. He formulates the problem of animal diversity and presents an explanatory hypothesis for this diversity and outlines certain predictions stemming from that hypothesis. The predictions are tested through careful analysis of actual information gathered from the study of palæontology, ecological zoogeography, systematics and related fields.

S. P. RAY CHAUDHURI

Man in Nature: MARSTON BATES.

Foundations of Modern Biology Series.

Prentice-Hall Inc., New Jersey, U.S.A., pp. i—xi+116, 1961.

The book *Man in Nature* is an important contribution in the field of elementary biology which will be valuable to both the students and the teachers. The book has brought out several advanced and specialised topics on Biology in relation to man, within the easy reach of the beginners. The selected topics which have been discussed are (1) man as an animal, (2) affinities of man to the Primates, (3) evolution of Primates and in turn the evolution of man from Primates, (4) the races of man and their geographical distribution, (5) the population of man in various continents, (6) the cultivation of improved varieties of useful plants and raising of domestic animals for human food, (7) the importance of plant pests in relation to human food, (8) the pathogenic organisms such as bacteria, fungi, Protozoa and worms which affect man's health, and (9) the material resources such as minerals, forests and maintenance of wild life, which have contributed to the present social life of man.

The book is well illustrated and the specialised topics are introduced in a lucid style to the beginners.

VISHWA NATH

Adaptation: BRUCE WALLACE and ADRIAN M. SRB.

Foundations of Modern Biology Series.

Prentice-Hall Inc., New Jersey, U.S.A., pp. i—xi+113, 1961.

All those interested in Biology know it too well how important is the relation between adaptations and organic evolution. Today countless plants and animals exist on earth each living in its particular environment. Even more numerous were certain past organisms which for some cause have left no survivors. The forms flourishing at any given time, past or present, may be said to have adjusted or adapted to their respective environment. Environment is never static. It keeps changing, howsoever little, for better or worse. The living species may as well continue to show adaptive changes, which when quite significant may lead to creation of new species. Those forms which show no adaptive changes, or for some other cause, may suffer partial or total extinction. Therefore, the subject of adaptations forms an important facet for the study of evolution. And to this effect the above-mentioned book is rightfully devoted.

The book under review is one of the eleven monographs published in Prentice-Hall Foundations of Modern Biology Series. It is designed to present before the students and teachers of Biology some of the most modern views about the various aspects of adaptation. The authors of this work have successfully analysed the processes that lead to adaptation. It has not been their intention to deal with the description of any specific adaptations.

The introductory chapter of the monograph deals with the meaning and general scope of the term adaptation. In the second chapter the reader's attention is drawn to the vast variations which are always appearing in the offsprings of any living organism in spite of the fact that the offsprings tend to resemble their parents as closely as possible. These variations, as explained in this chapter, may sometimes favourably effect the reproductive ability in a particular population and, in that case, they lead to adaptations Chapter III is intended to familiarize the reader with the general principles of heredity. Here is given a simple account of the chromosomes and genes, which are units of hereditary characters. Chapter IV is devoted to explain the causes of variations and how far they can be effective in populations.

In chapter V the authors have attempted to show how populations of individuals may adapt to new environmental conditions. Formation of strains of bacteria resistant to certain antibiotics is the simplest adaptation that can be proved in the laboratory As explained in this chapter, this resistant strain of bacteria arises directly from any one or more such individuals which by virtue of their genetic variation have the property to escape the lethal effects of the particular antibiotic. But, most adaptations in nature are complex and they have long histories. Chapter VI of the book attempts to indicate that same general principles can be applied for the complex adaptations as in the case of simple adaptations, although it may be difficult to verify them by experimentation.

Chapter VII points out the effects of 'ecological niche' (set of living conditions) on the species. This embodies the understanding of natural selection. The successful variant populations with favourable adaptations segregate from each other little by little, ultimately leading to adaptive radiation. In a similar way the influence of any single environment in selecting similar functional abilities in different types of forms leading to superficial resemblance (convergence) has also been beautifully illustrated in this chapter.

Chapter VIII is devoted to the analysis of mutual adaptations of living things. This precisely explains adaptations leading to community life among animals or plants. Domestication of various species, as explained, is also a kind of adaptation, operating on the same principle of genetic variation. Chapter IX explains the possibility of the modification of reproductive behaviour on the basis of genetic variation. If two populations of any one species have diverged sufficiently so as to impart reproductive isolation, and their hybrids tend to be sterile, this may ultimately lead to divergence as two definite species. This idea has been beautifully brought out in this chapter.

Adaptations can be very temporary, such as those sometimes experienced during the life-time of an individual. These adaptations do not pass into the next generation. Nevertheless, the ability for such adaptation no doubt follows the usual pattern of genetics. And to this theme, is devoted chapter X of the book. Finally, in the concluding chapter the authors expose the limitations of adaptation, i.e , nature does not permit an overemphasis on any particular adaptation.

Overall, the book provides a delightful and informative reading. It is beautifully printed and nicely illustrated with figures. Everyone who is interested in organic evolution will find this book an excellent work. The short summary given at the end of each chapter, and a list of selected reading at the end of the book lend further grace to this publication.

H. S. VISHNOI

THE SCIENTIFIC BASE OF ECONOMIC DEVELOPMENT

P.C. MAHALANOBIS

Member Planning Commission, New Delhi

PHASES OF ECONOMIC DEVELOPMENT

The essential characteristic of an underdeveloped country is an extremely low level of living, that is, inadequate supply of food, clothes, housing, drugs and other consumer goods, and also lack of facilities for education, care of health, social security, cultural amenities, etc., for the nation as a whole. It is possible to make available small quantities of consumer goods, by direct imports or by production, on a small domestic scale, with the help of imported machinery. In most of the underdeveloped countries it is, however, not possible for lack of necessary foreign exchange to import or to produce, with imported machinery, enough consumer goods for the people as a whole. In India, the first textile mill was established in 1817; and India gradually became second largest producer of textiles, next only to America. One hundred and fifty years later, India would still remain underdeveloped. The production of textiles or small quantities of other consumer goods for a small part of the nation cannot, by itself lead to industrialization and economic development.

Economic development can occur only by increasing the per capita production of the nation as a whole, through an increasing use of machinery driven by steam or electricity as a substitute for human and animal labour. In countries with appreciable natural resources, it is necessary to establish the basic engineering and power industries to enable the manufacture of both consumer and capital goods within the country. Establishing a minimum complex of such basic industries would take at least ten or fifteen years, for which planning must start ten or fifteen years in advance.

To increase modern industrial production would call for an increasing supply of engineers, technologists, and technical personnel. The only way to ensure this would be to establish and increase the number of schools, training colleges and universities, and also to train teachers for such institutions. This would take at a least fifteen or twenty years so that, planning for this purpose must start fifteen or twenty years in advance.

The best way of utilising the raw materials and natural resources available within the country, for both domestic consumption and for export, can be found out only through applied scientific research.[1] Applied research, in its turn, must be based on advances in fundamental research. Also, to establish an adequate base for applied research it is neceassry to promote the spirit of pure research and supply the stimulus of scientific criticism. This would be possible only when at least a certain minimum number of scientists are engaged in fundamental research and opportunities for pure research are becoming increasingly available. It is therefore necessary to promote the advancement of both applied and fundamental research. To establish a minimum base for scientific research would take more than a generation of twenty-five or thirty years; this, being the most slowly maturing sector, must be given the highest priority.

THE SCIENTIFIC BASE OF THE ADVANCED COUNTRIES

The scientific base of the modern age can be appreciated by even a brief review of the recent history of the advanced countries. Four hundred years ago the generally accepted view was that the earth was at the centre of the universe; the position of human beings was unique and supreme, and the basic sanction of truth was either divine revelation or abstract logical reasoning in the mind of man. In the sixteenth and the seventeenth centuries, there was a complete revolution in the picture of the physical world; the earth was seen as a small planet moving round the sun; and the method of empirical observations and experimentation was gradually established in both physical and life sciences.

Progress was at first slow in the sixteenth century. A few selected names may be recalled to indicate the gradual transformation of ideas. In astronomy, Nicholas Copernicus (1473-1543) supported the view that the planets including the earth itself were revolving in orbits round the sun. Tycho Brahe (1546-1601) supplied astronomical observations of unprecedented accuracy to make the next steps possible; Johann Kepler (1571-1630) formulated the descriptive laws of planetary motion; and Galileo Galilei (1564-1642) made conscious propaganda in favour of the new philosophy of the universe. In anatomy, Andreas Vesalius (1514-64) published his observations on the human body in 1543; in physics, William Gilbert (1544-1603) gave an account of magnetism based on trustworthy experiments in 1600; in physiology, William Harvey (1578-1657) described the circulation of the blood in 1628; John Napier (1550-1617) supplied a convenient tool for computation by the use of logarithms; and René Descartes (1596-1650), a philosopher, contributed the powerful concepts of coordinates for geometrical representation and of mathematical functions. Francis Bacon (1561-1626), firmly stated that the only true method in science was to proceed from particular sense observations to wider generalizations (*Novum Organum*, Book I, xix), and clearly recognised that 'the true and lawful goal of the sciences is...that human life be endowed with new discoveries and power.'

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[1] Even the most advanced countries are obliged to devote large resources to research for the improvement of products already being manufactured and also to develop new products in order to hold their position in the world export market. It is not possible for the underdeveloped countries to start or expand the export of fully or partly manufactured products by simply borrowing the current technology from advanced countries; it is essential also to develop applied research for a continuing improvement of technological methods.

The concept of an objective world of physical reality gradually took firm shape in the seventeenth century in the hands of gifted astronomers, mathematicians and scientists. A few names may be mentioned from among those who were born in the first half of the century ; Pierre Fermat (1601-1665), Christian Huygens (1629-95), Blaise Pascal (1623-62), Robert Boyle (1627-91), John Ray (1627-1705) Robert Hooke (1635-1703), Issac Newton (1642-1727), and Gottfried Wilhelm Leibniz (1646-1716). The rate of advancement of science increased progressively in the eighteenth and the nineteenth centuries, and during the last few decades has opened new frontiers with almost unimaginable possibilities

The advancement of science prepared the ground for the industrial revolution in Europe in the eighteenth century, first in spinning and weaving, next in the use of iron and steel, and then of electricity in the nineteenth century, which stimulated the growth of the capitalist economics in West Europe and North America. The spread of the scientific outlook also prepared the ground for the age of reason and the French revolution, which occurred at the end of the eighteenth century, and promoted the growth of nationalism in Europe, in its modern sense, in the nineteenth century.

The industrial revolution increasingly replaced human and animal power by steam or electricity to drive machinery for the increasing production of both consumer and capital goods. The development of engineering techniques led to a close linkage between science and technology ; and during the last hundred and fifty years, industrial development is being stimulated by a scientific discovery or a scientific discovery is being stimulated by industrial needs.

For the last five or six thousand years, or more, the average per capita production remained more or less constant or fluctuated within narrow limits. The industrial revolution changed all this, and led to a spectacular increase in the variety and volume of goods produced. As a consequence of such increasing production, the standard of living of the advanced countries of West Europe and North America reached a level far higher than the rest of the world. Also, the advancement of science, technology and industry, made it possible for the western countries to become strong military powers ; and, because of such military supremacy, the west was able to bring a large part of the world either into direct colonial rule or into conditions of economic-political subjugation

The last forty years have also seen the rise of U.S S R., as another world power, rapidly growing, through the promotion of science and technology, in economic, industrial and military strength together with a continuing increase in the level of living. The monopoly of scientific and technological knowledge and the unchallengeable military supremacy of the western countries has [illegible]. The increasing parity between the "western" and the "eastern" powers in science, technology, industry, and military power is a most [illegible] [illegible] of the present time. Because of the unprecedented destructive power of atomic and nuclear weapons, it has become absolutely necessary to avoid a nuclear war which would be catastrophic for both sides and the whole world. Co-existence of both the "western" and the eastern" powers has become indispensable.

There is no intention on either side to make a direct attack. The advanced countries pose no special problems because it is not possible to hold such countries indefinitely in subjugation. However, so long as there are underdeveloped areas both power groups are likely to try to extend their influence over the less advanced countries; and this would remain a continuing source of potential conflicts. The very existence of underdeveloped countries should, therefore, be seen as a threat to peace. Rapid transformation of all the underdeveloped countries into modern viable societies is an essential condition for peaceful co-existence. Such a transformation would promote the enlightened self interest of both power groups and would also create conditions favourable for the advancement of human and cultural values on a world-wide basis.

THE ROLE OF SCIENCE IN THE MODERNISATION OF THE LESS ADVANCED COUNTRIES

Modernisation of the less advanced countries through rapid industrialisation is thus an urgent need for the whole world. Is such modernisation possible or can a modern society with a viable economy, with expanding social and political freedom, and cultural amenities, be sustained without establishing a sound scientific base? This is a question of crucial importance for the present [illegible]

In order to answer this question, it is necessary to appreciate the deep changes in human thinking which were brought about by the emergence of science. In every sphere of organised activity in human society, authority has always been associated, and must always be associated with a system of hierarchical levels. This applies to primitive societies, matriarchal, patriarchal or tribal; successive levels of feudal lords; organised churches and religions; military, police and administrative systems; enterprises, business and commerce; and law. A law court of appeal may reverse the decision of a lower court; but the decision of the court of appeal is itself subject to change by a still higher court. The decision of the highest court, to which a case has been actually referred, has to be accepted not because such a decision is necessarily right, but because it is the decision of a superior authority [2] Society must accept this authority principle for stability and orderly progress, even in organised revolutionary activities.

This very authority principle must, however, be absolutely and completely rejected in the field of science. Modern science is based on a patient accumulation of facts, on the study of processes and their interrelations or interactions and a stability or uniformity of nature[3] which can be discovered by the human mind The findings of the most eminent scientists are subject to critical check by their professional colleagues and by the youngest scientific workers, and must be rejected if there is no satisfactory corroboration. Science can advance only through free criticism on a completely democratic basis, with every research worker of competence enjoying equal status The theoretical or conceptual framework of science must be continually revised to find a proper place for all known facts. A single new observation may call for a more comprehensive theory. The older accumulated knowledge continues to remain valid, later discoveries must, however, be integrated with the earlier knowledge The accumulation of scientific knowledge is increasing through the efforts of all the scientific workers of the world A new fact may be observed or a new theory formulated by any worker, however young, and in any country where research has been established International collaboration is, therefore, an indispensable condition for the progress of science.

Authority derived from status is irrelevant to science. Science has introduced a new concept of 'scientific', or 'objective validity' which has its foundation in nature itself, and which cannot be upset by any authority based on status or by supernatural powers. The transformation of all the advanced or rapidly advancing countries has been based on accepting, in an increasing measure, a scientific or rational view of life. This is the foundation of [illegible].

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[2] It is possible, indeed, that this decision itself would have been reversed if there had been a still higher court to which the case could be referred. If a decision of a higher court of appeal is considered to be like the turning up of 'heads' (in tossing an unbiased coin) when the decision upholds the verdict of the lower court, and is considered to be like the turning up of 'tails' when the verdict of the lower court is reversed, then the successive decisions of the higher court would look like the results of the tossing of a coin. This would be the real guarantee that the system of law is functioning properly.

[3] The phrase 'uniformity of nature' must be, of course, interpreted to include chance events and random processes. Although games of chance were known and were widely prevalent in ancient times in China, India and other countries, it is important to note that the concept of probability did not arise until the 16th and the 17th centuries, that is, not until the emergence of modern science. This is easy to understand. Before the emergence of the modern scientific view of an objective world of physical reality, all chance events would have to be necessarily ascribed to the whims of gods, demons, or supernatural forces After the emergence of the scientific view of an objective world of physical reality, it became necessary, both logically and psychologically, for the human mind to accommodate the occurrence of chance events as an integral part of the uniformity of nature This could be accomplished only on the basis of the theory of probability, or rather, as I should prefer to put it, only through a statistical view of the world. It seems to me, therefore, that the concept of probability, or the statistical view of the world, did arise at the same time as the emergence of modern science only because it could not possibly have arisen earlier.

It is essential in every country to establish and strengthen the outlook of science, a way of thinking which becomes more and more essential as it is more widely adopted, and which replaces dogma, superstition and outdated customs. This scientific outlook cannot be established by force. It must depend on acceptance through proper understanding. In practical affairs the important point is that a wise policy and programme of action should be increasingly adopted on the basis of rational argument, supported by relevant factual evidence, and should not be rejected because of emotional bias or formal dogmas or conventional rules of procedures. It is, therefore, necessary continually to encourage and promote the advancement of science in every country, large or small. Because science is indivisible, and also because science must be established in every country, it is also necessary, continually, to promote scientific collaboration between all countries of the world, large and small, and advanced or developing.

It is scarcely necessary to point out that there is no conflict between the scientific and rational view of life on one hand, aims and objectives based on moral or cultural values, on the other hand. On the contrary, moral and cultural values which are truly universal, and are narrowly sectarian or nationalistic in a restricted sense, must have an objective and rational basis.

The advancement of science and the growth of the scientific outlook must be recognised as an essential condition for the modernisation of the less advanced countries. It is necessary for each country to have, as quickly as possible, a sufficient number of men with a scientific outlook to influence the thinking of the nation. How to attract and hold a sufficient number of able persons to science is thus the crucial problem of national and world development. This can be achieved only through a proper and adequate social appreciation of science and scientists. The actual transformation must be brought about from within each country. Scientific aid from the advanced countries can, however, be of great help in this process.

PRESENT PROGRAMMES OF TECHNICAL AID

The need of technical aid has been recognised for some considerable time. Bi-lateral or multi-lateral and international technical aid has often taken the form of either offering educational and training facilities to young workers from the less advanced countries or sending technical or scientific experts to such countries. Considerable benefit has no doubt accrued through such aid but it is necessary to recognise that such effort has also been wasted.

Scholars from the less advanced countries are usually selected on the basis of results of examinations, success in examinations not being a necessarily reliable indicator of scientific or technical ability, the very process of selection is inefficient. Some of the young scholars have difficulty in adjusting themselves to the pattern of living in the advanced countries Some of them do not do well in their studies. Some pass the examinations successfully but have no aptitude for scientific work. Some of the more able scholars prefer to live and settle down in the advanced countries, especially in the U.S.A., because of the higher level of living or greater opportunities for scientific work. Some scholars of ability, when they return to their own countries, are unable to find suitable openings for a scientific career; and some of them go back to the country where they were trained. In applied science and technology, and especially in social sciences, many young scholars, who had often studied problems or learnt methods which are appropriate for advanced countries but totally irrelevant to their own native countries, are unable to adapt or develop methods to suit local conditions. Out of the large number of scholars who go to advanced countries for training, only a very small number of really able scientific workers ultimately become available for fruitful work in their own country. The cost of giving scientific or technological training in an advanced country is also very high. Giving training to individual scholars in advanced countries (whether the expenses are provided in the form of foreign aid or met by the scholars themselves or by the country of origin) have been, therefore, extremely wasteful in terms of both men and money.

There has been also continuing difficulties in finding suitable individual experts for the less advanced countries Competent scientific workers are reluctant to accept such assignments partly because of the lack of facilities for their own work in the less advanced countries and partly because their scientific or academic career is likely to be adversely affected through their absence abroad. In consequence, assignments sometimes have to be given to persons who are not fully qualified for the job, with unsatisfactory results To create suitable conditions for scientific work in the less advanced countries is an indispensable condition for attracting competent scientists to go out to such countries.

Programmed technical aid on a group basis has been more effective. A team of young engineers from a less advanced country can receive most valuable training in an advanced country when such training is oriented to specific technological projects. Teams of experts from advanced countries have also been of very great help in establishing factories or in starting new projects in the less advanced countries. Such technical aid, especially in engineering, technology and applied sciences, should be continued and expanded. Special projects for establishing technological and research centres in the less advanced countries have also been taken up by some of the international agencies. This type of aid can be of great value provided a sufficient number of scientific workers in the less advanced countries can be trained to work in such centres, and also provided necessary conditions are established to enable them to do their work properly.

SCIENCE EDUCATION AND RESEARCH

It has been argued in the earlier sections that for modernisation it is necessary to establish a foundation for scientific research and the social appreciation of science in the developing and less advanced countries. Every path-finder in a new field of research must work in the first instance by himself; if he is successful, other persons gradually get interested in the subject. Such path-finders always had, and will always have to overcome much opposition, and even hostility, until the new subject becomes a recognised part of the "established" field of science. But it is only a few scientists of outstanding ability who can work in isolation. Most research workers require the stimulus of free interchange of views and ideas and of appreciation among professional colleagues.

The community of scientists has a structure of a series of widening circles similar to the structure of scientific subjects or of science as a whole. When a top scientist speaks appreciatively of some work in his special field, other scientists or lay men accept his evaluation and pass on the information to others. The social appreciation of science gradually emerges as a result of the diffusion, in widening circles, of the views of scientists, who are experts in specialised fields of research, to scientists in related and associated fields, then to scientific workers generally, and finally, through persons of position and standing who have contacts with scientists, to the general public. The speed with which such appreciation can spread increases rapidly with the increase in the number of scientific workers and improvements in the channels of communication. In the advanced countries, the awareness of the importance of science is increasing rapidly which, in its turn, is raising the social status of scientists and is promoting an increasing flow of resources for research.

The whole process is extremely slow in underdeveloped countries. The number of research scientists is very small; and channels of scientific communication are non-existent or meagre. Scientific workers usually receive lower pay and have a lower status than the administrative staff in government or in business concerns; and have to work in a rigid system of hierarchical authorities. Promotion may depend, not so much on the high quality of the scientific work done, but on success in pleasing those who are higher up in the official hierarchy. Even permission to apply for posts elsewhere is subject to the discretion of superior officers. There is a continuing tendency to bring scientists and scientific work under stricter control of the administrators, partly, perhaps, from an unconscious fear of rivalry of power. Even if the right of criticism is accepted in principle, it is restricted in practice because scientific workers are often afraid, rightly or wrongly, of giving offence to persons holding higher posts. In consequence, many scientists in underdeveloped countries suffer from a lack of self-confidence, and are afraid to take up original lines of investigation. There is little possibility of a proper evaluation or appreciation of scientific work within the country. This leads to an exaggerated dependence on the opinion of foreign scientists and give rise to much imitative work. Also, when there is lack of appreciation or criticism from the advanced countries, there is sometimes a tendency to ascribe the unfavourable view to racial or national prejudices, and there is resistance against collaboration with foreign scientists.

In underdeveloped countries there are very few, sometimes only one or two, individuals of outstanding ability in scientific research or in any other scientific field. As leadership can be supplied only by individuals of high ability, and as such persons are few in number, it is much more difficult in underdeveloped countries to utilise the services of individuals of average ability and qualification. The advanced and advancing countries have a double advantage. They have a large number of persons with qualities of leadership and can, therefore, utilise in a fruitful way larger numbers of persons of average ability. This is why many scientific workers from underdeveloped countries, who are unable to do much useful work in their own native country, can often do very good wrok in the environment of a higher state of organisation of research in an advanced country.

The aim of scientific aid must be to create in every underdeveloped country, as quickly as possible, a sufficient number of research scientists to form a community of professional workers which would be sufficiently large to facilitate an independent evaluation of scientific work through free criticism and frank exchange of views. It is, therefore, necessary to focus attention on indentifying and giving support to persons who have the ability to undertake research work of high quality, and to try to increase their number as quickly as possible, and at the same time to offer opportunities for training to persons of average ability whose services would be equally essential in supplying a wide base for the pyramid of scientific work.

There is urgent need of fostering the spirit of objective scientific criticism through free expression and exchange of views and opinions. One effective way of promoting this would be to make it easy for scientific workers to migrate from one post to another and give an absolute guarantee of such freedom to migrate. Any scientific worker who feels, rightly or wrongly, that he has not enough opportunities for fruitful work in one institution would be free to migrate to some other institution. Such migrations or the possibility of such migrations would have an indirect but most important selective effect on scientists at all levels.

It is necessary to recognise that the social value of an individual scientist of high ability is far greater in a developing country because of the leadership he may be able to supply. It is only scientists engaged in fundamental research who can function as the eyes and ears of the nation in making the nation appreciate and identify urgent needs of applied research. The emergence of even one or two outstanding research scientists can enhance the prestige of the nation in a most significant way at the international level and promote the growth of self respect and self confidence of the nation This is why it is particularly important in developing countries to indentify such individuals, at first very few in number, and give them all possible facilities and encouragement to continue their work in their own country.

In the highly developed countries science advanced both from progress at the highest levels of research, at the top, and from the wide diffusion of education, at the bottom The same strategy may be adopted with advantage in the less advanced countries. What is urgently needed is to lay the foundations, with as wide a base as possible, for a country-wide system of school education oriented to science and, at the same time, to develop advanced studies of science and technology and research at the highest level. The school system must fit into the economic life of the general mass of the people and have its grass roots in the villages. It must offer facilities for training technicians and technical personnel for science and technology and also supply candidates of outstanding merit for admission to higher scientific and technological institutions.

NEED OF DIRECT AID FOR SCIENCE

I shall offer, briefly, a few suggestions for giving direct aid for the development of science in the less advanced countries. I have stressed the need of building up a system of school education with a definite orientation to science. It would be, however, a fatal mistake to establish an expensive system of education on the model of the advanced countries which would have little relevance to local needs and would be beyond the means of the national economy. It is necessary to evolve a system, through experimentation and trial and success, which would be within the means of the national economy. The approach must be therefore, to use teaching aids with are easily available or can be made available on a large scale and at a low cost. As most of the pupils will be living in villages, it would be of great advantage if agriculture and some of the rural industries can be adopted as a base for the teaching of science. The programme may consist largely of nature studies, observations, and experiments which can be done with the help of simple articles, specimens, etc., likely to be locally available or which can be constructed with local materials.

There would be still some need of supplying teaching aids and materials from outside which would have to be specially designed to reduce costs. It is essential also to prepare books of instructions and text books to suit a fairly wide range of needs. These are difficult tasks which would call for extended study and research by scientists of high calibre with a serious interest in problems of science education. As basic conditions in underdeveloped countries are likely to be similar to a large extent, it may be possible to evolve broad general methods for science education which would be capable of being adapted without much difficulty to suit differing local conditions

A great deal of pioneering research would be necessary for this purpose for which the help of advanced countries is indispensable. A good deal of experimental studies will have to be undertaken under conditions actually prevailing in underdeveloped regions. In the beginning, the studies would have to be organised on a small scale with the help and support of the local authorities and of such teachers and scientists as may be available to cooperate in the venture in the underdeveloped country itself. The project can be gradually extended, in the light of experience, to cover different subject fields at different educational levels, and also from one underdeveloped country to another. Fortunately, even one or two scientists can start the work in one single country. The important point is to make a beginning at the earliest opportunity.

I may now mention a second type of programme. Certain facilities for scientific research are already available in India and other developing countries. In most of these countries, scientific work is being hampered for lack of small replacement parts, additional accessories and instruments, and supply of essential consumable stores which have to be imported from the advanced countries. It is often difficult to secure import licences on account of shortage of foreign currency. This difficulty can be overcome through a simple plan of gifts in kind of replacement parts, instruments and equipment, stores, books and journals and reprints or microfilms of scientific papers etc., to be arranged through non-governmental committees of scientists. Such committees, which can be set up in the advanced countries through or in cooperation with appropriate scientific organizations or societies, would try to secure suitable grants from Government and other sources. In developing countries where scientific research has already started, the counterpart committees of scientists would also be set up, preferably, at a non-governmental level and with a majority of members from universities and non-governmental scientific institutions. All arrangements would be made with the concurrence of the government of the less advanced country concerned, but decisions relating to gifts for scientific work must be made by direct consultations between the scientific committees themselves. A scheme of this type can be usefully started, on an experimental basis, for a few selected countries, at a low cost, with gifts to the total value of perhaps one or two hundred thousand dollars per year. The amount can be increased if the experiment proves successful.

Another important form of scientific aid would be to arrange for competent research scientists from the advanced countries to work for a year or two in existing research units in the less advanced countries or to help in establishing high level research units in such countries. The less advanced countries can offer challenging problems and opportunities for research in many fields of science, which cannot be duplicated in the advanced countries, for example, in geology, meteorology; biology, botany, and zoology; agriculture; medical science and public health; economics of development, linguistics, archaeology, and historical and cultural studies of various kinds. In some of the developing countries there would be also increasing opportunities for active participation in research in mathematics and statistics, and physico chemical and technological sciences. In establishing research units in underdeveloped countries it would be desirable to keep one broad aim in view, namely, to encourage joint studies by active collaboration between different research units. This would help in developing a community of research cells or units which, in its turn, would foster the growth of the spirit of scientific criticism and appraisal among wider circles of scientific workers.

To attract competent visiting scientists it is necessary to offer them facilities to pursue or start fruitful research in the less advanced countries; sometimes special equipment may have to be provided for this purpose. Secondly, the assignment in a less advanced country, would have to be treated as deputation in the same way as participation in scientific expeditions, and which would be recognised as a part of normal duties and also as a possible qualification for promotion. The visiting scientist must receive sufficient compensation in his home currency to meet his continuing home commitments during his absence abroad. Living and other local expenses should be normally met by the institution or by the government of the country in which he would work. Such sharing of costs would promote effective cooperation in the less advanced country, and would also reduce the total cost appreciably.

An important part of the responsibilities of a visiting scientist would be to give training to the scientific workers of the underdeveloped countries. When necessary, the visiting scientists would be able to select, for further training in an advanced country, the right type of persons who can be depended upon to go back to their own country after the completion of the training abroad. It would be also possible to give aid in the form of equipment and instruments in an effective way on the basis of objective appraisals of needs and possibilities by the visiting scientists.

A fourth programme could be to send from advanced countries young scholars, who have just finished their education in universities or higher educational institutions or have already done some research, to start or continue suitable lines of research for about two years or so in existing institutions or in research units to be established for this purpose in underdeveloped countries. The common participation in research projects of young scholars from the advanced and the underdeveloped countries would be of great help in establishing scientific traditions and an atmosphere of scientific criticism. It would promote self-confidence among the scientific workers of the underdeveloped country, especially, if the visiting scholars from advanced countries take higher degrees from institutions in the less advanced countries.

All the above forms of scientific aid can be started, if desired, on a small scale and at low cost, and, if successful, can be expanded in the light of experience. Also, these forms of scientific aid would not in any way overlap or hamper bigger programmes for gifts of expensive equipment or large projects for the setting up of national or regional centres and institutes for scientific research in the less advanced countries. On the contrary, the modest programme described in this note would prepare the ground for bigger projects.

CONCLUSION

In conclusion I may refer, very briefly, to some recent developments. After the second world war the movement for terminating colonial rule gained rapidly in strength ; and one country after another in Asia and Africa has won political independence. It is being increasingly realised, however, that independence is not enough for economic development. The need of economic and technical aid is also being increasingly appreciated. Both the 'western' and the 'eastern' powers have started helping in the economic development of the less advanced countries in Asia, Africa and Latin America, but still without an adequate impact. The time has come to recognise that economic aid is essential but is also not sufficient.

Revolutions to capture political power have been occurring throughout human history and are even now occurring in many of the politically independent countries in Latin America or in most of the newly independent countries in Asia and Africa. Such revolutions do not automatically promote rapid economic development, because purely political revolutions do not lead to any fundamental transformation of the old society based on the principle of authority associated with levels of status. It is becoming increasingly clear that rapid economic development cannot be achieved without developing a structure of society in which decisions would tend to be made more and more on grounds of reason, that is, in accordance with the principle of objective validity instead of authority. It is relevant to note that the French Revolution was preceded by the age of reason ; the American War of Independence had the support of influential leaders inspired by the spirit of science ; and the socialist government, which was established after the October Revolution in 1917 in Russia, made great efforts to build up a country-wide system of science-oriented education and to promote scientific research and, in this way, succeeded in modernising the whole society leading to rapid economic development.

One thing is clear. In the absence of rapid economic development, political conditions in the less advanced countries would remain unstable. In many or most countries there would be one revolution after another tending to get the two power groups involved directly or indirectly in the struggle. The world must get out of this vicious circle. There are only two possibilities. One is for a violent type of revolution to occur which would suddenly change the whole structure of society to make it fit for rapid development of science and economic progress The other alternative is deliberately to build up the foundation of science oriented education and research to promote the modernisation of society in a peaceful way, and make conditions favourable for economic development.

Aid for scientific and economic development from either the western or the eastern countries, even when given in a spirit of competition, would be cooperative in effect. In any event, competition in constructive tasks of building up scientific foundations in developing countries is less dangerous and is likely to be far more useful than competition in the methodologies of warfare. Also, collaboration in promoting education and research in pure science can be pursued without any threat to national security or national interests, and would be of great help in promoting a rapid advance of the underdeveloped countries and in fostering better understanding among the nations of the world. The advanced countries have a great opportunity for peaceful cooperation in giving aid for science.

This pamphlet was first printed as a pamphlet for private circulation. Certain aspects of these problems were discussed by me in articles and addresses between 1955 and 1959 which were reprinted in *Talks on Planning* (1961), and in other articles such as *A Note on Problems of Scientific Personnel* (1959), *Recent Developments in the Organisation of Science in India* (1959), and a lecture at Sofia University in December 1961. Some of the ideas given in this article were presented by me before a Conference on International Cooperation in Salzburg-Vienna in July 1962.

Professor P. M. S. Blackett in his presidential address to the British Association for the Advancement of Science in 1957 and in other articles in *Nature*, (3 February, 1962 ; May 1962 etc.) has considered various problems from point of view of the advanced countries. Professor Stevan Dedijer made a penetrating analysis in the article in *Nature* (6 August 1960) and in another article published recently in Stockholm, *TVF*, 33, (1962).

SCHOOL MUSEUMS AND CHILDREN'S MUSEUMS

S. T. SATYAMURTI

Superintendent, Government Museum, Madras

Nothing is perhaps so exciting for a group of school children doing their daily routine of class work as to be let loose in the spacious galleries of a museum on a Saturday afternoon and to be allowed to brouse around, revelling in the visual feast provided by the interesting multiplicity of exhibits. I would be hardly surprised if these children, on completing their tour round the museum, are tempted to think, "Isn't it a fine idea to try and make a small museum of our own in our school at least a highly reduced miniature of what we have just seen ?" Yes, it is a perfectly legitimate ambition, and it is the duty of every teacher and schoolmaster to help the children, to fulfil that ambition. In recent years the value of school museums as visual aids in education has been increasingly recognized, and it is by no means an exaggeration to say that a small museum of educational exhibits should constitute a vital part of the equipment of a school—almost as essential as a good library or a spacious sportsfield.

SCHOOL MUSEUMS

It is gratifying to learn that some schools in India have been very successful indeed in building up their own museums. But a large number of schools, owing to lack of accommodation, finances and other facilities, remain altogether without this valuable asset. Yet others are blissfully content with what are apologies for museums, for all that they can boast of by way of a museum is a rickety, dust-laden almirah crammed with a few ill-shaped stuffed birds advanced in the process of losing their feathers, some old unnamed and incomplete skeletons and a jumble of all sorts of zoological odds and ends which require the services of an expert systematist to classify and identify. But there is no need to despair. I may emphatically say that it is possible for every school, no matter how mediocre its financial means might be, to build its own museum which may prove to be a valuable aid in our present scheme of practical and craft-centred education.

The teachers and pupils who set about organizing a school museum will naturally be faced with numerous problems, and the magnitude of the initial difficulties might tend to stifle the enthusiasm of the amateur museum builder. "Where am I to procure the requisite materials and specimens from ? How can I have them properly preserved, mounted, arranged, labelled and displayed ?" Such are the questions that are likely to baffle him at the outset. In the present article I have endeavoured to give a few practical hints that may prove helpful in organizing a school museum, but it should be realised that a certain amount of practical training in museum methods of preservation and display is always necessary if one is to make a real success of this fascinating job. Facilities for such training can always be arranged in consultation with the authorities of large public museums which may have the necessary staff and the resources to afford such guidance.

The Starting of the Museum

One of the essential pre-requisites for building up a school museum is a spirit of unflagging industry and enthusiasm, coupled with an infinite capacity to hurdle over minor difficulties and obstacles. It is necessary that someone on the staff of the school, preferably the science master, should get himself actively interested and take the initiative in the matter. It would be an excellent plan if he could get together a few industrious and interested young pupils to assist him. A 'Museum Club' could be started, and it would be the primary duty of the members of this club to do all they can to collect material for the school museum. Most children have the collecting instinct strongly developed in them, and this could be conveniently canalised into useful and constructive channels for the enrichment of the school museum collection by proper training and guidance.

Field Trips and Excursions

The value of field trips, excursions and outdoor camps as aids in enriching the collections of the school museum can hardly be overestimated. It is on such occasions that children get an opportunity to make a first-hand study of nature, and the pleasurable adventure of collecting, together with the knowledge and experience gained from such trips are in themselves ample rewards for the trouble and expense they might have involved. The collecting party should provide themselves with adequate equipment such as butterfly nets, shovels, long pairs of forceps, insect killing bottles, corked glass tubes and other receptacles and plenty of preservatives such as 70% alcohol and 4% formalin stored in well-stoppered jars. A knowledge of the probable situations where one might expect to find the specimens one is looking for will go a long way in enabling the young collector to make the most of his field trips and amass a rich collection. Hills are particularly suitable places for the collection of large and brightly coloured species of butterflies such as the Swallow-tail. Beetles may be found under decaying logs of wood and similar damp situations. Several species of birds such as herons, egrets, ducks and waterhens take their abode among trees and bushes in the vicinity of ponds and lakes. Such localities may afford an excellent ground for bagging a handsome collection of birds, provided one is equipped with a small gun. Marine collecting also has a fascination of its own. It is a delightful experience to wade through ankle or knee-deep water in lagoons around coral reefs at low tide and pick up the beautiful, multicoloured tokens of Nature's manifold treasures. such as shell-bearing molluscs, starfishes, sea-anemones, jelly-fishes, sponges, corals, marine crabs and shrimps. Even a leisurely walk along a sandy beach, particularly in the vicinity of backwaters, might yield an interesting collection of shells and other hard animal remains of marine creatures which get washed up on the beach. While out on such field trips it is advisable that every pupil should maintain an observation book in which he may jot down notes on the living animal, such as its colour in life, movements, habits and other peculiarities of ecological interest.

Preserving Specimens

Unfortunately it is not possible for me to describe in detail in this limited space the various methods of collection and preservation of museum specimens. Taxidermy and other museum methods of preservation and mounting are highly technical jobs requiring considerable skill and experience, and, as I mentioned earlier in this article, it is necessary for the teachers to maintain contacts with the authorities of the larger public museums for information, training and guidance in these methods. The Madras Government Museum has recently published a Handbook of Museum Technique, edited by Dr. A. Aiyappan and Dr. S.T. Satyamurti, and the British Museum (Natural History) has issued a number of handy guide booklets for the benefit of those engaged in collecting and preserving museum specimens. These publications contain a wealth of practical information and helpful instructions for collection of museum specimens and builders of small museums, and it would be advisable for every school interested in building up a museum to procure copies of these handbooks. It should be borne in mind that the material gathered through collecting trips have not only to be preserved properly, but have also to be identified scientifically and carefully labelled, giving particulars of the name of the species, its locality and date of collection, for a specimen without a label loses much of its scientific value. This may be done by referring to, and comparing with, the specimens stored in the larger collections contained in the public museums of the city. A modern museum maintains a study collection, apart from the exhibits in the public galleries, particularly for the use of students and teachers who require help in identification. The authorities of such large public museums will only be too glad to offer all the assistance they can in naming and suitably setting up the collected material for use in the school museums.

Planned Organisation

It is not unusual for a school museum to rapidly dwindle down into a mere meaningless miscellany of unrelated objects and curiosities after the initial impetus of the organiser has subsided a little. Such a state of affairs has to be carefully guarded against. It is absolutely necessary for the museum builder to have in view from the very beginning a clear and well defined plan as to what kind of exhibits he should collect and prepare, and he should be able to arrange them in a definite order so that the whole collection may tell a harmonious and connected story, correlated to the lessons taught in the school. The material exhibited in the school museum would naturally prove most useful if they are so selected and arranged as to have a direct bearing on the syllabuses of the various subjects taught in the school. For instance, few visual aids could be more effective in a lesson on the feeding habits of birds than a well selected series of beaks and feet of various Indian birds which can beautifully illustrate the correlation between structure and habit. Similarly, a series of preparations of mammalian skulls may graphically illustrate how the cat's teeth are adapted for tearing flesh, while the rabbit's are more fitted for nibbling grass. An enlarged model of the head of a poisonous snake will certainly help in impressing the pupils and enable them to understand the mechanism of the poison apparatus in snakes far more effectively than a plain diagram.

A small collection of local birds and small mammals, lizards, frogs and fishes butterflies, beetles, grasshoppers, spiders, snails and other lower animals collected from fields and gardens in the vicinity of the school will form excellent exhibits if they are suitably preserved, mounted and displayed, and will serve to give the children a concrete idea of the common types of animals represented in their local fauna. It is exhibits such as these that the organiser of a school museum should aim at preparing, for eventually they would turn out to be of immense practical use as illustrative material for the teachers while taking their lessons. Generally, a small vivarium and an aquarium in which living terrestrial and aquatic animals are kept and reared will be found to be useful adjuncts to the school museum as they afford an excellent opportunity for the children to watch their movements, breathing and feeding habits, and life histories, before they are killed and preserved for the museum.

I have so far restricted my remarks mainly to zoological material but they are equally applicable to other school subjects such as botany, history and geography. Plants, economic products, minerals, coins or plaster casts of coins and other objects and curiosities of educational value may also be similarly collected and set up for the school museum. Apart from trying to collect by their own efforts, the teachers and pupils may also try various other sources. Large public museums, industrial concerns and other Government Departments such as the Forest, Fisheries, Veterinary, Agricultural and Public Health Departments might be able to make small gifts of specimens to school museums The Fisheries Biological Supply Stations will be able to secure specimens of marine animals at a nominal cost. Exhibits such as relief models of the various districts, a partly sectioned model of the globe showing the crust of the earth and specimens of the common minerals and ores represented in our country may prove to be of immense value in illustrating lessons in Geography. Similarly, a series of Indian coins or their metal casts or plaster casts arranged and labelled chronologically will form an exhibit of considerable historical value, helping the children towards a better understanding of the various important dynasties. A representative set of such electroplated metal casts of the coins of India are available for sale at the Madras Museum for the benefit of schools. A good collection of our local plants and economic products derived from them may help to impress on the pupils our great indebtedness to the plant kingdom and also enable them to get clear and correct ideas about the structure and characteristics of many of our common plants, with which most children, specially residents of the cities, are so unfamiliar.

The Museum Room

When a fairly decent and representative collection of material has been gathered together for the school museum, a good, well-lit and well ventilated, preferably rectangular room in the school buildings should be selected for accommodating the museum. It would be necessary to exhibit the specimens, models, etc., in suitable show cases with large, uninterrupted glass fronts, arranged along the walls, to ensure proper production of the exhibits and at the same time allow a good view of the exhibits. While planning the show cases, uniformity in style and suitability to the nature of the material to be exhibited should be the guiding principles in their construction. Good labels are essential for museum exhibits. Printed labels bound with glass and passe-partout are ideal, but neat, handwritten India ink labels are also good enough if printed ones are not available. Typed labels are liable to rapid fading. Once the nucleus of a school museum has been laid, it can be expected to develop and expand rapidly into a veritable storehouse of practical knowledge, provided the teachers and pupils actively co-operate in contributing all their skill, ability and ingenuity towards its enrichment.

Children's Museums

One of the recent developments in the sphere of museum activity, especially in western countries, is the organization of special museums and galleries, catering exclusively to the needs of children. In the United States of America, for instance, such Children's Museums have become increasingly popular in recent years, and a large number of them have sprung up all over the country. They serve as lively centres of educational activity for children of all age groups, apart from being show places for housing selected exhibits planned specially for children. Opportunities for handling the actual objects and for creative activities such as painting, model-making and other hobbies are provided, and the whole panorama of life is made more real to the children through such displays, film shows, lantern lectures, demonstrations, dramatic performances and other activities. The average American school boy or girl is also fortunate in being benefited by the extensive educational services organized by the larger public museums in the cities. These services include circulating collections of various illustrative material such as lantern slides, educational motion picture reels, and specially prepared portable exhibits for class use. School Museums in the West have therefore had far greater opportunities for developing on modern lines than those in our country.

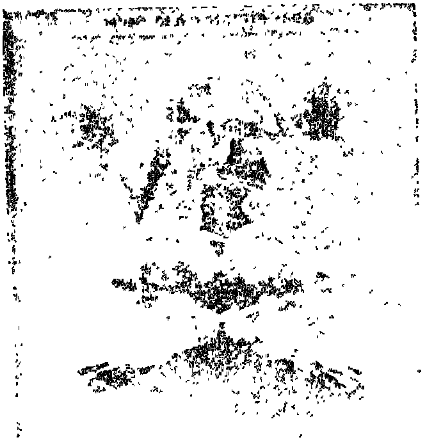
Dressed dolls illustrating Yugoslav traditional costumes, exhibited in the Children's Gallery of the Madras Government Museum

Children's Gallery in the Madras Museum

In India, unfortunately, apart from one or two isolated instances, there is hardly any museum service catering exclusively to the needs of children, and very little progress has been made in this direction so far. Public museums are few and far between, and are too understaffed to render any appreciable help to the hundreds and thousands of schools all over the country. Our schools therefore have to depend more or less entirely on their own efforts in developing their museums. However, it is gratifying to record that the Madras Museum, which has already to its credit an enviable record of educational services, has taken the lead in this novel sphere of museum activity also, and has established a very attractive and instructive Children's Gallery in the recent past. It contains many useful and educative exhibits including dioramas of reduced scale models of extinct animals, enlarged models illustrating the internal structure of the earthworm, frog, pigeon and rabbit, a working model illustrating the circulation of blood in the human body, models of the human digestive and respiratory systems, and enlarged, dissectable and demonstrable models of the human brain, heart, eye, ear and other sense organs. These exhibits help to make some of the basic lessons in animal and human biology vivid to the children. Dressed dolls showing traditional costumes of various States of India and even of some other countries form an additional attraction to the children in this gallery. A Science Section, equipped with working models, is an indispensable part of a modern Children's Gallery, but only a beginning has been made in this direction in the Madras Museum. With a view to fulfilling this need, a number of scientific exhibits have been acquired, to start with. These include a series of specimens and photographs

A doll illustrating a characteristic pose in Bharata Natyam in the exhibit entitled "Dances of India" in the Children's Gallery of the Madras Government Museum

illustrating the story of glass in its various forms, the Spitz Junior Planetarium, capable of projecting a realistic image of the starry skies in a darkened room, a working model of an internal combustion engine, two globes worked by electricity, one illuminated by an internal bulb, and the other, a rotating one, with a model of a man-made satellite revolving round the globe, the relative speeds of the motions of the earth and the satellite being accurately depicted in this working model which the visitor himself can operate. Towards the end of the gallery, the story of the development of human transport is graphically unfolded in a series of accurate scale models mounted against suggestive case backgrounds. The models include those of ancient as well as modern forms of transport and serve to present a composite picture of the evolution of human transport in a comparative way. It is observed that the Gallery is continuing to grow in its popularity especially with children, and it has not only proved to be a recreative centre but also a powerful instrument of visual education to the children. But it should be remembered that the present Children's Gallery in the Madras Museum is only a



Enlarged Model of a Dissected Frog Exhibited in the Children's Gallery of the Madras Government Museum

nucleus, and it will be expanded and more completely organized in the next few years when a special building is expected to be constructed for it.

The purpose of the Children's Museums and Children's Galleries is to fill up efficiently the lacunae in the facilities provided by schools, libraries and playgrounds for the harmonious development of the child's personality. Their activities should not overlap those of other organizations, but should rather aim at supplementing them. Children's Museums are an entirely new approach to the problems of child education. The value of the Children's Museum lies in its flexibility, and it is just this factor that makes it unique among educational organizations. It is well known that modern trends in education tend to stimulate a greater desire on the part of the child to know his world and to explore himself, and it is the Children's Museum that is most admirably fitted to provide him with his laboratory and the necessasy tools for achieving this end.

FOSSILS AND THE ANCIENT HISTORY OF THE HORSE

H. S. VISHNOI

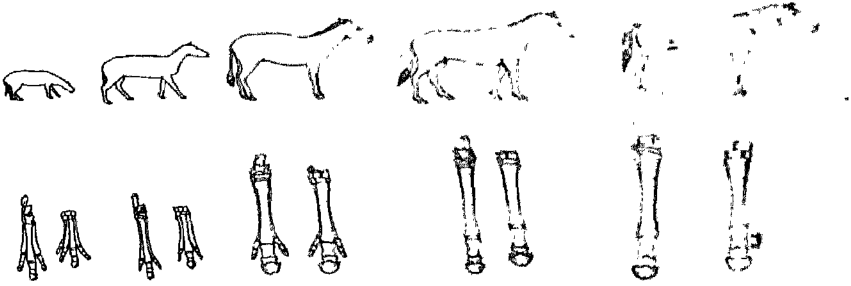
Zoology Department, University of Delhi.

Organic evolution is one of the most fascinating subjects in biological studies. Among the various evidences sought in favour of organic evolution, the most important one is available in the form of fossils. The fossils are the remains or indications of life which once existed but now extinct. These fossils are the hard parts of the animals or plants that have been petrified or transformed into stony material, and which have been preserved in the rocks or strata of the earth. Sometimes, the fossils may only be in the form of moulds in the rocks, i.e. the imprints left by the organisms. The science of fossils is called palaeontology. From the detailed study of fossils it may be possible to reconstruct the full body-outline of a particular animal that is now extinct.

Fossils have immensely helped the biologists in establishing links in the evolutionary history of several animal groups.

Archaeopteryx, an extinct bird, which had many striking similarities with reptiles supports the derivation of birds as a group from reptiles. It may also be possible to discover the sequence even in the evolution of a single species. Some success in this direction has been achieved in tracing the ancestry of *Homo sapiens*, the modern human species. But the most complete and convincing evolutionary history that has so far been revealed by palaeontology is that of the modern horse. The most cogent reason for this is that the fossil record of horses is very complete and very well understood.

The entire sequence of horse's progressive evolution is traceable from North America. The first horse belonged to Eocene period about 45 million years ago. This horse is named *Hyracotherium* (also called *Eohippus*; Gr. *eos*, dawn, *hippos*, horse). It was a prototype of all horses. This was a short animal about the size of a small dog, but its limbs were well-built for running. Its back was curved and the tail shortened. Among many other primitive features in its skeleton, this ancestor of the horse had the most spectacular characteristic in its limbs. The feet were elongated, with the wrist and ankle well raised above the ground. The weight of the body rested only on the tips of the toes each of which terminated in a small hoof. There were four toes in the front foot and three toes in the hind foot. The chief peculiarities in teeth were : small size of incisors, presence of canine, and simple and small premolars



The evolution of horse. Upper row, restorations of the body ; lower row, bones of hind and fore feet.

From the ancestral form like *Hyracotherium*, commenced in one direction the evolution of modern horse which is chiefly characterised by increased size, long legs and feet, persistence of a single middle toe, shortening and stiffening of the back, widening of incisor teeth, loss of canines, molarization of premolars, increase in the height of the crown of teeth, and increase in size and complexity of the brain.

A series of fossil records are available today which indicate a gradual evolution from the ancestral form of horse to its present form by progressive acquisition of the above characters of modern horse. Through a few other stages, came *Mesohippus* in Oligocene about 30 millions years before. This horse was about the size of a sheep. It was well adapted for speed. It had only three functional toes in both hand and foot; the middle toe, however, was the largest and the lateral ones weaker which bore less of the animal's weight. The premolar teeth of this horse had largely become molar-like. These horses had an extensive dispersal and some even migrated to the Asian continent presumably through the land bridge at the Bering Strait.

Merychippus, which actually is the seventh stage in the direct line of horse evolution was about the size of a small pony. It was common in Miocene, about 15 million years back. In this horse, both feet retained three toes although the side toes were now reduced so much that they remained above the ground without supporting the body. Vestiges of this kind of non-functional toes can today be found even in cows and buffaloes as small nodules above and behind the hoofs; in these animals, however, the evolution has occurred along a different line.

Pliohippus was, in a way, quite close to the modern horse. It existed in

Pliocene, about 5 million years back. This had clearly become a single-toed horse. The side toes were reduced to thin splint bones hidden beneath the skin of the upper portion of the foot. This condition continues even in the modern horse.

Equus, the modern horse, is the tenth and final stage which first appeared in Upper Pliocene about 2 million years ago. In this, the well-developed splints of the second and fourth digits still persist and are situated only at the upper end of the cannon bone which itself is the elongated middle metacarpal in the front foot and the middle metatarsal in the hind foot This horse has survived into modern times in the form of a number of species like the asses, zebras and horses.

In this way a series of fossils of ancient horses help us building up a sequence in the evolutionary history of modern horses. There is always an attempt by the palaeontologists to discover as many of the fossils of a form as possible and to interpret their position in the evolutionary tree of life. What might seem strange and unbelievable is sometimes beautifully and realistically illustrated by the fossils.

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MAMMALS

VISHWA NATH

Professor Emeritus, Punjab University, Chandigarh

In this article I wish to tell you something about the group of animals which go by the popular name of mammals or are included under the scientific name *Mammalia*. You must be already knowing what a mamma (pl. mammae) is. A *mamma* is the milk-secreting organ of the female in mammals, it has a *teat* or *nipple* to enable the young one to suckle or feed by sucking the milk of the mother. In the males the teats are present, but the mammary glands do not develop.

Mammals constitute the highest group of animals and man is the most highly developed mammal and therefore the most highly developed animal.

Another characteristic feature of the mammals is the possession of *hair*. Indeed hair are to mammals what feathers are to birds. Both hair and feathers are epidermal outgrowths, i. e. both develop from the outermost layer of the skin (epidermis) although both are nourished by a vascular (adjective of vessel) papilla of dermis (layer of the skin below the epidermis). The papilla contains blood vessels, and the dermis contains both blood vessels and nerves. Because of the existence of nerves in the dermis (which also form nerve papillae below the epidermis) we feel pain when our hair is pulled.

There are a few mammals which, on a casual study, seem to be devoid of hair, but a closer scrutiny shows that they are present but are very scarce. A most outstanding example of a mammal which has lost its hair is the *whale* which you must know is an aquatic (marine) mammal and not a fish. In the whale hairs have been lost except for a few bristles on the face.

Another feature of the mammals is that they are warm-blooded like birds, maintaining like the birds, a constant temperature (homoiothermous) in contrast with the Reptiles (lizards, snakes, tortoises, alligators etc.), Amphibia (frogs, toads, salamanders etc.) and Fishes whose body temperature tends to vary in relation to external temperature (poikilothermous or the so-called 'cold-blooded' animals).

Again, all mammals except Monotremes or Prototheria are viviparous. That is, the young are born after a shorter or longer period of sojourn in the womb of the mother (period of gestation). During gestation a thick vascular cushion called the *placetna*, which is partly foetal and partly uterine (i e. from uterus or womb of the mother), is formed. Through the placenta the blood vessels of the mother communicate with the blood vessels of the foetus. Thus the foetus is nourished by the mother, and through the same agency the mother removes the excretory products of the foetus. A great burden is thrown, therefore, on the mother during the period of pregnancy. No wonder that this long period of pregnancy has given rise to the maternal affection for the young, which is one of the most powerful factors to which mammals owe their phenomenal success and supremacy.

We shall talk about the Monotremes in some future article Here, it will suffice to mention that this group comprises only two living genera, viz. *Tachyglossus* (*Echidea*) or the Spiny Ant-eater and *Ornithorhynchus* or the Duck-billed Platypus, both inhabitants of the Australian Region. The Monotrémes are often called ''living fossils', as some of their characters are reptilian and some mammalian. They, therefore, show us the way which some fossil reptiles, ancestral to the mammals, travelled to be modified into full-fledged mammals.

Again, all mammals possess a muscular partition, the *diaphragm*, cutting off the pleural and pericardial cavities (containing the lungs and the heart respectively) from the main abdominal cavity containing the stomach, intestine, liver, spleen, pancreas, kidneys, testes or the ovaries etc. In deep breathing the diaphragm is made to move up and down, thereby exercising the intestine, in addition to cleaning the lungs and through them the blood with a plentiful supply of oxygen.

In all vertebrates above the fishes, i.e. in amphibia, reptiles, birds, and mammals, there is a middle ear which is surrounded on the outside by the tympanic membrane (or the drum of the ear) and on the inside by the box containing the internal ear, the essential organ of hearing. The cavity of the middle ear is not completely closed off; if it were, the drum of the ear would burst on account of the atmospheric pressure. On the contrary, it communicates with the mouth-cavity by means of a narrow canal called the Eustachian tube. This equalizes the pressure in the middle ear with the atmospheric pressure.

Now in Amphibia, Reptiles, and Birds there stretches across the cavity of the middle ear a thin rod of bone called the *columella* whose inner end fits into a hole (*fenestra ovalis*) in the wall of the box of the inner ear, and whose outer end rests on the inner surface of the tympanic membrane. This membrane is made to vibrate by the sound waves, and the vibrations travel to the internal ear *via* the columella, the wall of the box of the internal ear, the *perilymph* (a fluid surrounding the internal ear), the thin wall of the internal ear (also called the membranous labyrinth), and finally the *endolymph*, a fluid filling up the cavity in the labyrinth. Finally the vibrations reach the special cells with long sensory hair which are essential organs concerned in hearing. These sensory cells are supplied profusely with the fibres of the auditory nerve; hence the vibrations reach the brain.

On the contrary, in the mammals there are three pieces of bones (auditory ossicles) forming a chain across the cavity of the middle ear instead of only one (the columella) of the Amphibia, Reptiles, and Birds. These ossicles are: (1) the outermost *malleus*, (2) the middle *incus*, and (3) the innermost *stapes*. The stapes is homologous with the columella, while the malleus and the incus probably represent respectively the *articulare* (a bone of the lower jaw) and the *quadrate* (a bone of the skull) which have shifted into the cavity of the middle ear and taken on a new function altogether.

The lower jaw consists in mammals, of a single bone, the *dentary*, while in the lower vertebrates there are many bones in the lower jaw.

In most vertebrates the vertebral column or the spine consists of pieces of bone called *vertebrae*, lying one behind the other. A typical vertebra consists of a thick, stumpy lower part, the *centrum*, and two neural arches which meet above, enclosing a section of the *neural canal* which lodges the spinal cord. Now a characteristic feature of the mammals is that each centrum consists in the young state of three pieces,—a middle part which is thickest and is the *centrum proper*, and two thin discs of bone, the *epiphyses*, an anterior and a posterior, which fuse with the main piece during growth.

Again, in mammals the skull presents a single vacuity, i.e. a *single lateral temporal fossa*, exactly as in some extinct reptiles which show the various stages through which the mammals evolved from the earliest reptiles.

The skull has towards its hind end two *occipital condyles* (thickenings) which fit into two concavities at the front end of the *atlas*, or the first vertebra.

The teeth are lodged in sockets, and they are modified into *incisors, canines, premolars,* and *molars*. Again, there are two sets of teeth, *milk* and *permanent*.

Finally the *heart* is four-chambered like birds, with a single aortic arch (the main systemic trunk) which, however, is the *left* one and not the right one as in birds. Again, in the mammals there is no *renal portal system*, i.e. there is no vein from the tail region which breaks up into capillaries in the tissues of the kidney to emerge as the renal veins.

The *red blood-corpuscles* of mammals are characteristically *non-nucleated*.

LEARNING DIFFICULTIES IN BOYLE'S LAW

P. S. KAPOOR

Science Consultant, Madhya Pradesh, Bhopal

Boyle's Law is the relationship between the pressure and the volume of a perfect and dry gas. A perfect gas is one which cannot be liquified at a certain temperature by simply compressing it. It is one which obeys Boyle's Law and Charle's Law. All substances which are in a gaseous form are not perfect gases. All of them do not obey Boyle's or Charle's Law. Oxygen is an example of a fairly perfect gas but carbon-di-oxide is not Hydrogen is as close an example of a perfect gass as could be.

The product of pressure and valume of a perfect gas at a fixed temperature remains constant.

P × V is constant. (Boyle's Law).

In the class room while teaching this relationship, a student encounters a large number of difficulties with respect to its functional understanding.

They can be enumerated as below :

(a) The pressure of the atmosphere.
(b) The measurements of pressure in terms of the height of mercury column and the absolute pressure.
(c) The kinetic theory of gases.
(d) The inverse proportionality of the pressure and volume
(e) The calculations involved in finding P, V, and P × V.
(f) The drawing and interpretation of graph showing the relationship between pressure and volume.

In this paper an attempt is made to analyse the learning difficulties of the topic taking into account the above stated facts.

Definition

Learning is present whenever there is any relatively permanent change in the behaviour of an organism, as a result of its reaction to environmental influences. Through the action of the environment upon us, primitive tendencies become modified and new tendencies are produced

For the Gestalt Psychologist, learning is chiefly a matter of coming to see relations. He has to see, within one compact pattern, both the problem to be solved and the means of solving the problem. To him learning consists of acquiring 'means-goal' Gestalts, or pattern. Once the pattern is formed, learning ceases to be a problem.

Learning difficulties are all those which offer resistance to the change in the organism's behaviour. They offer resistance to proper assimilation of new facts and ideas. They may involve the acquisition of skills—reading computation, gathering facts relating to some material or phenomena, comprehension of concepts, and ideas, and formation of functional vocabulary. The new learning forms a superstructure of the old which forms the apperceptive mass for the new. The new should be so linked with the old as to become an extension of the old. For the proper interpretation of the varbal statements it is necessary to relate them to the first hand concrete experience with the real material or phenomenon. This is an important learning difficulty.

Background

(1) The class should know the meaning of directly proportional and inversely proportional. This would be developed as below :—

(a) If we travel at a constant speed, the distance travelled would be directly proportional to the time taken. The more the time of travel, the more would be the distance travelled.

(b) When we read before a lamp, the nearer we are before the lamp the better we see. The clarity for reading would then be inversely proportional to the distance In this case it varies inversely as the square of the distance.

(c) Experiments have shown that the time of vibration of a pendulum is directly proportional to the square root of its length and also inversely proportional to the acceleration due to gravity i.e. $T \propto \sqrt{l/g}$ where l is the length of the pendulum and g is the acceleration due to gravity.

To equate this relationship it has been found that by introducing a constant 2π this relationship holds true. This 2π is called the constant.

In that case the relationship in the form of equation would be ;

$$T = 2\pi\sqrt{l/g}$$

So we find that a proportionality can be changed to equality by introducing a constant.

(2) Gas is a matter. Matter is made up of molecules. Molecules are so small that in 1 cubic centimeter of a gas there are no less then 25×10^{18} molecules.

The space between the molecules is much larger than the molcules them selves. The molecules fly about in all directions with great velocity. The blows which the innumerable molecules of a gas strike against the surrounding walls causes the pressure. When a gas is compressed to half the volume, the pressure is doubled because, doubling the density, doubles the number of blows struck per second against the walls.

(3) Pressure of air is measured in terms of the height of the mercury column.

(4) Force is a push or pull and is measured in dynes or newtons. It is calculated with the formula :

$F = A\ h\ D$ where F is force, A is area, h is depth and D is density.

(5) A mercury barometer measures the pressure of the atmosphere.

(6) Pressure is force per unit area and is expressed as—

$P = F/A$ where P is pressure, F is force and A is area

$P = H\ D$ where H is the depth of the liquid column and D is its density.

Pressure of a column of liquid is equal to the weight of the column on the area of the cross section of the tube containing the liquid. The weight of the liquid column is proportional to its height and its density, which is fixed for the particular liquid. Hence the pressure is represented in terms of the height of the liquid column.

(7) The volume of the gas or the air column is proportional to the radius of the tube and the height of the column and is represented by :

$V = \pi r^2 h$, where V is the volume, r is the radius, and h is the height of the cylindrical tube.

$V = A\ h$ where A is the area of the cross-section

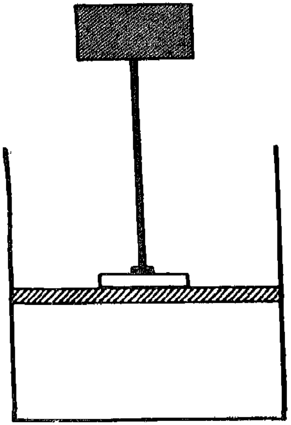
(8) What happens when 4 cubic inches of air at atmospheric pressure are in a bicycle pump of area 1 sq. inch, and it is compressed at twice the atmospheric pressure ? What would happen to the volume of air ? What would happen if the pressure is released ?

***Problem* :**

What is the relationship between the pressure and volume of an enclosed gas when the temperature is constant ?

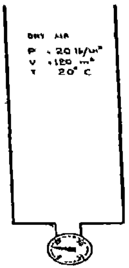
Main Body of the Lesson :

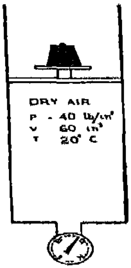
(A) A demonstration experiment may be set up as shown in the diagram. The piston is assumed to be leak proof and to move freely in the cylinder.

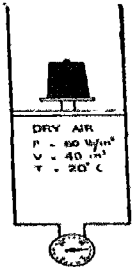


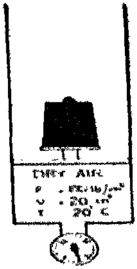
What happens when the weight is increased ?
What happens when the weight is decreased ?
What happens when the weight is removed ?

(B) Another demonstration may be set up with a gauge fixed at the lower end of the cylinder and the weights increased.









The piston is assumed to be leak proof and to move freely in the cylinder. Pressure indicated by the gauge includes that of the atmosphere which pushes downward on the piston.

(a) Notice the original values of pressure (P) Volume (V) and Temperature (T).

(b) When the original pressure is doubled, how does the volume change? How does it compare with the original volume?

(c) When the original pressure is multiplied by three, how is the volume changed now?

(d) When the original pressure is multiplied by four, how does the volume change now?

(e) What about the number of molecules in all the four situations?

(f) What about the number of molecules striking the surface of the piston?

(g) What about the speed of the molecules striking the piston?

(h) How are the pressures compared in all the situations?

(i) How about the weight of the air in the piston in all the four cases?

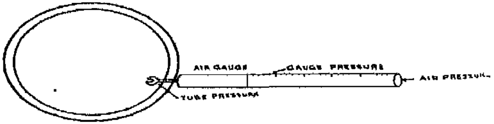
(C) A discussion and demonstration of the working of a gauge be held.

(1) Where does the pointer on the gauge stand when it is not connected to the inflated tube but exposed only to the atmosphere?

(2) When it is connected to the inflated tube, what does the reading of the gauge indicate now?

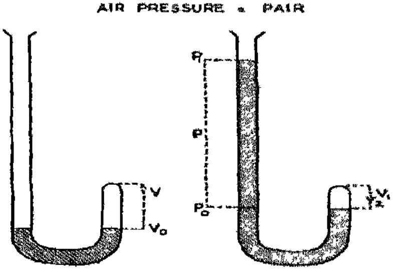
When the gauge is fixed to the valve of the inflated tube, the inside air exerts pressure and the gauge reads it. On the gauge there are two pressures, one from the inside of the tube forcing it out and the other of the outside air which forces it to get in.

We can express it in a vector diagram as follows :—



Air Pressure Tire pressure Absolute pressure.

Resultant Gauge pressure



What do you conclude from this ?

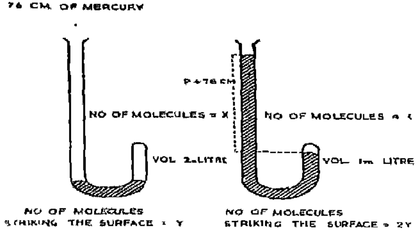
Absolute pressure—Air pressure=Gauge pressure

OR Absolute pressure=Air pressure+Gauge pressure.

(D) With the help of a few questions the idea of the J—tube apparatus be developed.

(i) What is there in the Torricellian Space in a Barometer tube ?
(ii) (Introducing a bubble of air in the tube) What change has now taken place in the level of mercury ?
Why has the mercury level fallen down ?
(iii) How can you, therefore, enclose some air in a closed space ?
(iv How can the air be dried before enclosing it ? (By passing it through quick-lime)
(v) Why is it necessary to have dry air ?
(vi) After enclosing the necessary amount of dry air in the closed arm of J—tube, and getting the mercury level same in both the arms ;
How does the mercury level compare in both the arms of the J—tube ?
(vii) What is the pressure of mercury in the open arm ?
(viii) What is the pressure of mercury in the closed arm ?
(ix) How can we measure this pressure of the atmosphere ?
(x) By increasing the mercury column in the open arm of the tube, what change has taken place in the pressure of the enclosed air ?
(xi) What change has taken place in the volume of the enclosed air ?
(xii) When pressure increases how does the volume change ?
(xiii) When pressure decreases how does the volume change ?
(This be done by taking out some mercury from the open arm.)

(xiv) How about the weight of the enclosed air ?
Does it change ?



(E) In the two situations stated in (D) above, the number of molecules, their mass and their velocities remain unchanged in both the situations. The space occupied by the molecules in the second situation is half the space occupied in the first, but the number of molecules per unit volume has been doubled in the second case. Accordingly the number of molecules striking against the surface of mercury has changed. In half the volume, twice as many molecules as before would strike each square centimeter of the surface of mercury in the tube per unit time. Hence the air would exert twice the force on the same area as originally. Therefore, the pressure in the latter case, when the volume is halved, would be double that of the former.

(F) How can the value be measured in the J—tube apparatus for demonstrating Boyle's Law ?

Let V_1 be the reading of the top end of the closed arm of the tube and V_o be the reading of the mercury column in the closed arm ;

What would be the volume of the air enclosed ?
It would be :
$V_1 - V_o = V$

What would this volume be equal to in terms of the radius and the height of the air column ?
It is :
$V = \pi r^2 h$
or $V = a h$ (where a is the area of the cross-section and it is constant)
or $V \propto h$

(G) How can the pressure be related in terms of the height of the mercury column ?

On the J — apparatus mark the mercury column that locates the pressure Read P_1 and P_0.

How is pressure represented ?

$P_1 - P_0 = P$

(H) Do the two columns of mercury in the J-tube balance each other ? Why ?

($P = h\,d$; If the tubes on both the sides have the same diameter and h on either side is the same, h=h and d=d, then P = P)

(I) How can length of mercury column represent pressure ?

$P = hd$

If d is the same for both sides or if we say that d is constant then,

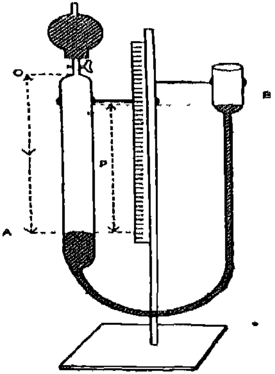
$P \propto h$

(J) What is absolute pressure ?

Absolute pressure = Air pressure + Gauge pressure

$P_{ab} = P_a + P$

(K) After dealing with the above stated points the improvised apparatus as shown in the diagram be made use of in the demonstration which would be conducted with the active cooperation of the class. A few students may help the teacher in lowering or raising mercury reservoir and take the readings. The class be stirred up with the questions about the functioning of the apparatus, the use of calcium chloride tube, the graduations on the burette and reading of the scales, and the precautions necessary during the experiment.



The burette temperature be recorded before and after a sudden decrease in volume of air.. Care must always be taken when changing the reservoir to each new position to allow several minutes for the gas to come to the room temperature. The necessity of doing this is that on compression the gas gets warmer and on expansion it cools.

It be emphasised here that we are concerned with the change of pressure with respect to volume or vice versa and hence the need of waiting for some time to read the different scales till the temperature in the burette comes to the room temperature

What would be the absolute pressure of the air inside the burette ?

It would be the sum total of the atmospheric pressure and the gauge pressure. When the mercury level is higher in the reservoir (gauge) than in the burette,

$P_{ab} = P_{air} + P_1$ (Difference of levels of mercury $= P_1$) When the mercury level is higher in the burette than in the reservoir,

$P_{ab} = P_{air} - P_2$ (Difference of levels of mercury $= P_2$) Why ?

This has to be elicited from the students.

Thus

$P_{ab} = P_{air} + P$ (Difference of levels of mercury) How would you get the volume readings ?

The difference between the two readings O and A, would give the volume readings.

Volume $\propto$ h

Volume $=$ O $-$ A

The changes in the volume be made and the corresponding pressure be noted.

The readings be tabulated in the form below. The pressure of the atmosphere be read with the help of a barometer. Suppose it is 74 cm. of mercury.

O	A	B	B—A	$P_{ab} = P_{air} \pm P$	V	P×V
90.0	62.0	41.2	—20.6	53.2	28	1489.6
90.0	66.0	53.9	—12.1	61.9	24	1485.6
90 0	70.0	70.6	.6	74.6	20	1492.0
80.0	64.0	83.1	19.1	93.1	16	1489.6
50.0	38.0	88.2	50.2	124.2	12	1490.4

What conclusions do you draw from these readings ?

What happens to the volume when the pressure is increased ?
What happens to the pressure when the volume is decreased ?
What happens to the pressure when the volume is increased ?
When the reading of the volume is 24 what is the pressure ?
When the reading of the volume is 12 what is the pressure ?
How are they compared ?
How about the weight of the enclosed gas ? Does it change ?

(When the volume is 12 the pressure is nearly double of the pressure when the volume is 24. The slight difference may be due to the errors in readings)

What can you say about the relationship between the pressure and the volume ?

You can say that the pressure varies inversely as volume or that the product of pressure and volume is the same. We can say that it is constant with respect to the air in the burette at that particular temperature

$P \propto \frac{1}{V}$ or $PV = $ Constant (Say K which is called a constant of proportionality)

You can see that the product of P & V in the last column is fairly constant within the limits of the experimental error.

Let P_1 and V_1 represent the first trial readings.
And P_2 *and* V_2 *represent second trial readings.*
What relationship exists between them ?
We find that :

$$P_1 V_1 = P_2 V_2$$

Divide both sides by P_2,

$$\frac{P_1 V_1}{P_2} = \frac{P_2 V_2}{P_2} = V_2$$

Divide both sides by V_1

$$\frac{P_1 V_1}{P_2 V_1} = \frac{V_2}{V_1}$$

$$\text{or} \quad \frac{P_1}{P_2} = \frac{V_2}{V_1}$$

What can you say from this ?

We can say that the pressures are inversely proportional to the volumes.

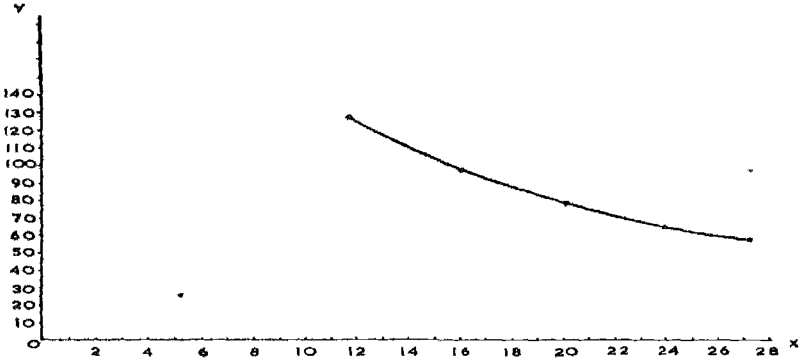
This is *BOYLE'S LAW.*

(The same experiment will be repeated with moist air and an untrue gas, such as water vapour. Each time it will be observed that the above relationship does not hold good. Hence the emphasis that the Boyle's Law holds good only for air and true gases when they are dry.)

(L) Let us now draw a graph from the readings obtained above, taking volume on the axis of X and pressure on the axis of Y and note the shape of the graph.

Is it a straight line graph ?

If it is a curve, what can you say about its smoothness ?



The graph is a smooth curve.

With its help you can say the relationship between the pressure and volume. You can read what would be the volume at a particular pressure or what would be the pressure for a particular volume.

(M) Suppose by applying extreme pressure, the volume of the gas is very much reduced, would the Boyle's Law still hold good ?

Would the doubling of the pressure at that stage make the volume still half ?

The answer to it is that the molecules under very high pressure are forced too close together to make this possible. (Experimental aid be taken to prove these facts as true)

(N) For the assimilation of and the mathematics of the Boyle's Law the students be given a few problems to solve

Problem 1 :—

A truck tire holds 5 cu. ft. of air. The gauge pressure is 75 lb/in^2. Find the volume of the air when it is released at 1 atmosphere.

Solution :—

$P_1 = 75 + 15 = 90$ lb/in^2
$V_1 = 5$ Cu. ft.
and
$P_2 = 15$ lb/in^2 ($P_2 = 1$ atmosphere pressure $= 15$ lb/in^2
We know that
$P_1 V_1 = P_2 V_2$
By substitution :
$90 \times 5 = 15 \times V_2$
or $V_2 = \frac{90 \times 5}{15} = 30$ cu. ft.

Problem 2 :—

A truck tire holds 5 cu. ft. of air when the gauge pressure is 90 lb/in^2. What volume af air at 1 atmosphere had to be pumped into the tire ?

Solution :—

$P_1 = 90 + 15 = 105$ lb/in^2
$V_1 = 5$ cu. ft.
$P_2 = 15$ lb/in^2
$V_2 =$?
$105 \times 5 = 15 \times V_2$
or $V_2 = \frac{105 \times 5}{15} = 35$ cu. ft.

The following problems may be assigned :—

1. What pressure must be exerted on 1200 cm^3 of Oxygen at one atmosphere pressure to reduce its volume to 600 cm^3 ? 400 cm^3 ? 300 cm^3 ?

2. We measure 500 cm^3 of a gas under a pressure of 750 mm of mercury. What volume will this gas occupy if the pressure is increased to 800 mm of mercury ?

3. An automobile tire holds 100 litres of air when its gauge pressure is 75 lb/in^2.

(a) What volume of air at 1 atmosphere will have to be pumped into the tire ? (1 atmosphere=15 lb/in^2)

(b) What will happen to the tire if it be taken to the top of a mountain where the 1 atmosphere pressure is 14 lb/in^2

4. An automobile tire is filled with air (15 lb/in^2 pressure) at atmospheric pressure, until the pressure gauge reads 35 lb/in^2 pressure. Assuming that the tire does not change in size and the temperature remains constant, what volume of air must be forced into the tire ?

METHOD OF LEARNING IN SCIENCE

PAUL VERGHESE

Principal, Government Training College, Trichur

All knowledge and understanding of the materials and appliances of practical life and of the phenomena of the world of matter and force must be ultimately based on our personal experience, either in perceiving events, or the actions of other people and their effects, or more directly by ourselves acting on things and noting what happens. Experience of one kind or another must be the source of all meaning and understanding of physical reality, although thought and imagination can transform experience into the higher and more universal plane of general law and theory.

The primary mode of learning, therefore, is to gain experience of the physical world around us by 'acting on it in various ways and noting what happens'. This is instinctively the young child's mode of learning. He acts on various things in a variety of ways, either on his own impulse, or in imitation of, or under the direction of others, and thus gains an ever increasing experience of the behaviour of things and substances under various conditions. It is true that in certain fields he has little, or no experience, e.g. in the properties and action of magnets, frictional electricity, chemical action, generation of electricity, surface action, etc. He, however, comes to school with a fairly extensive experience of materials, force, motion, heat, light, sound, and uses of electric currents. Such experience is of necessity inexact, indefinite, and superficial. It has been subjected to little analysis and organisation by thought. It is merely a loose mass of experience relating to the things of evey day life, and to its practical purposes. It is the aim of science teaching to extend this experience, to make it more exact, clear and full, to organise it into general laws, and to rationalise it through explanation and theory. To quote Dewey, 'Science is experience being rationalised'.

It is clear, then, that one important method of learning science must be:—

The gaining of exact and clear experience in fields in which the boy has little experience by the primary method of "acting on things and noting exactly what happens," e.g., acting on chemical substances with water, heat, or acids and noting what happens:

Observing more clearly and accurately what happens in situations in which they have experience, e.g., friction, pupils have a fairly extensive experience of friction by sliding, sledging and bicycle brakes. There is need, however, for more exact experimentation to make clear and exact the conditions that determine friction. Similarly with levers, action of forces, etc. The starting point in all such enquiries must of course be in the recall and examination of the experience they already have

Knowledge, however, can advance far beyond the plane of perceived facts. By thought the intelligence can probe behind facts to those factors and conditions that are hidden, obscure, and frequently unperceivable. For example, we can directly experience the upward force necessary to support a solid body by the hand and to move it upwards; but we cannot perceive the upward force that supports a ship, or that causes a cork to rise in water, or a balloon in air. Only thought can reveal these obscure and hidden causes of events that are familiar to all. If the teacher is to guide his pupils' thought in revealing these hidden causes, he must know how such thought proceeds.

It is a psychological truth that an unknown situation is interpreted by, and in terms of, the known on the grounds of some similarity or analogy of the unknown to the known. For example, suppose we are faced with the problem of finding the cause of a ship floating on water, or a cork rising on water, or a balloon in air. If we call to mind the experience that a solid body requires the upward force of the hand to support it and raise it, we can infer by analogy that water is exerting an upward pressure to support a ship, and cause the cork to rise, and also, that air is exerting an upward pressure in supporting and raising a balloon.

It is by such inferences from analogy that the intelligence is able to form conceptions of those conditions and forces operating in the world of reality that are hidden from preception, but the understanding of which is the key to our grasp and mastery of the world of matter and force.

Such inferences are, however, only of the nature of suppositions or hypotheses. They are not established truths. Inferences from analogy are not logically infallible, and must be subjected to test to see if they will work under other circumstances and conditions. Hence the test takes the form of arguing : "If it is true, what would happen under this, that, or other circumstances?" For example : If water exerts upward pressure, what should happen if an object that sinks is weighed in air and in water? Or if air presses upward, what should happen to a column of water, if we arrange to bring the upward pressure of the air to bear on its lower surface?

Such experiments test and verify or disprove our suppositions. They test our thought. They form the dramatic crisis to which our creative thought works, and they decide and resolve the issue of true or false.

The essence of this second stage of scientific method is:—

(a) Examination of some situation familiar to the pupils to reveal some specific problem.

(b) Search in the past experience of the pupils to find some apt analogy that will bear on the problem.

(c) Examination of the analogy to make clear the idea examplifies, and the application of this idea to the problem to form a suggested explanation

(d) Investing an experimental test that will verify or disprove the suggested explanation.

It is the art of teaching to stimulate, help and guide the pupils in this process of examination, suggestion, and verification, and of final expression in concise notes and diagrams.

The essential nature of the scientific method is thus clear. It is quite true to say that the natural sciences are observational and experimental studies. They are just essentially studies demanding thought and imagination. Observation and Experiment provide the basis of Facts of Experience from which Thought starts; Experience provides the analogies by which Thought infers possible explanations; and Testing Experiment gives the facts that verify or disprove our imagined suppositions; but it is Thought that leads our understanding to the grasp of what causes lie behind the world of Sensible Experience.

AUDIO-VISUAL AIDS IN TEACHING SCIENCE

S. P. MUKHERJEE
David Hare Training College, Calcutta

The use of audio-visual aids in the teaching of science is recognised everywhere now-a-days. In order to make the abstract ideas really meaningful to students, the teaching of science should be built around concrete experience as far as practicable. Pupils should see and examine objects in order to gain clear and accurate concepts of the scientific principles. Visual aids are used to help exposition and give illustration and exercise for verbal statements. Pictures, diagrams, models and specimens can be actually brought into the classroom for observation and study. The children themselves may also on the other hand, be taken to museums, picture galleries, factories and other places of scientific interest with a view to enabling them to study objects in their natural settings. Audio-visual aids to teaching science should be properly used in order that they may be really helpful as a teaching device. The teacher must know beforehand what exactly the aid is expected to illustrate. The main purpose of the lesson together with the key points must be determined. It will not be enough if only some aids are displayed. The educational purpose for utilising any teaching aid in science should always be kept in view and the teacher must give proper explanation along with his demonstration, otherwise, the aid will remain abstract and serve as a mere amusement. Audio-visual aids in science teaching are only means to an end. They cannot illustrate each and every kind of topic. They should suit the stage of mental development of the pupils. The teacher should take particular care in the selection of visual aids in order that they may be really educative. A farily large number of audio-visual aids to teaching science are now available for use in our schools. The use of some of these aids will be discussed here in detail.

SCHOOL MUSEUM

We shall first of all say a few words about the School Musem. Children must be aquainted with the nature of the environment and interrelationship with man. The appreciation and understanding of the surroundings come through observation and personal contact. These cannot be gained merely by reading about things. It, therefore, becomes important to bring the outside world into the classroom and laboratory through concrete representation of things. In this respect a school museum has a very important role to play. A school museum offers opportunity to develop the natural instinct of children for collecting and hoarding. The museum should ordinarily be a collection of pictures, charts, and diagrams procured by the teachers and students from various sources such as journals, newspapers, advertisements and books. The museum should also include collection of models, specimens, coins, insects, rocks, butterflies, moths, and pressed plants. Various products of industry available in the locality may also find a place in the school museum. Besides, some improvised apparatus and appliances may be displayed in the museum and whenever required, demonstrated in the classroom. The demonstration of apparatus prepared by the pupils always ensures keener interest and better understanding. School science museums can be started by individual teachers even though school funds are not readily available for the purpose. The samples in any science museum, to be of educative value, should have materials which must be attractive, easily seen and clearly labelled, having necessary information printed on them. The collections should also reflect the interest of the pupils. In the case of every exhibit, the name of the donor, when and where it was found and the reason for displaying it must be given. The important thing which teachers should remember is that they may not convert a science museum into a dull, dead and dirty collection. The museum exhibits should invariably be changed from time to time as they become old and worn out by constant use. The exhibits of a science museum, if prepared in a well-planned manner, stimulate the pupils who prepare them, as well as those who also observe them, to further study

EXCURSIONS

Excursion to museums and other places of scientific interest may be made a very useful aid to teaching science. Excursions are intended for teachers and pupils to study objective materials, located in their natural setting. Excursions enable pupils to examine things and study their relationships to make appropriate associations. The students should have an idea of the purpose of any school journey undertaken by the teacher whose duty will be to guide their observation. Excursions should be organised with an eye to the regular instructional work in the classroom. In order to use the excursion, as an aid to teaching science, the teacher must be well-acquainted with the resources of the place to be visited, as also the facilities offered by it for students who want to visit it. The visit to a museum or a factory or any industrial plant is to be organised either at the beginning of a unit of lesson or at the end. In any case, pupils should better interpret what they see and at the same time ask more intelligent questions as a result of such visits. Classes may be divided into groups of 15 or 20 and taken to an industrial plant where they may be given proper guidance throughout the visit. Much good result ensures if it is possible to link the materials to be observed with classroom subjects at all school levels. Great care should be taken to see that a student may not be required to learn more than what they can comprehend. High points of the excursion should be discussed either at appropriate intervals during the excursion or as soon afterwards as possible. Facts not thoroughly understood should be clarified and wrong impressions should be corrected. Pupils should be encouraged to ask questions and follow the discussions as they observe thing. They must have the proper mental attitude for study during an excursions.

PICTURES, CHARTS AND DIAGRAMS

Pictures, charts or diagrams are devices for visual representation of more abstract ideas and scientific principles There are certain things which pupils can never experience in reality and these can only be represented by charts or pictures which enable pupils to examine even complicated relationships. A single glance at a picture or chart enables the pupils to understand the meaning of the whole thing quite easily. For example, with the help of charts, it is not difficult for childern to visualise important relations which they cannot understand in other ways. A chart may be built up to illustrate an industrial process in science or to summarise several lessons' work. Pictures and charts can convey a number of ideas within a small space. They are also very useful in introducing new scientific topics. The presentation of any new material with the help of pictures will convey basic ideas quickly and clearly. The teacher may sometimes build even a whole lesson by presenting a series of pictures one after another. Of course, the conception of ideas will have to be supplemented by the teachers' explanation as well as text-books. The presentation of abstract ideas is a very difficult task with which science teachers are faced. It is only through maps, charts, pictures and diagrams that the most intricate and complicated processes are made easily comprehensible and these also arouse curiosity for many other related things and hence serve as a stimulus to fuller study.

FILM STRIPS AND FILMS

The film-strip which is another aid to teaching science is generally thought of as a pictorial teaching device. This is valuable because it furnishes visual materials that remain in the view of the pupils as long as it is necessary to permit all of them to examine it thoroughly and to analyse other necessary details. As a teaching aid, film-strips may be used to sharpen the students' power of observation if only these are presented through clear, interesting pictures that are rich in details. But if the pictorial element of the film-strip is deficient in detail, definition or clarity, it may fail to contribute to the students' knowledge and thus serve to inhibit learning. For effective use of film-strip as an aid to science teaching, the following points may be kept in view :

(a) Preview in order to become thoroughly familier with its content so as to realise how it relates to the topic. This also calls for reading the accompanying guide if there be any. A film-strip is to be selected only if it fits into the planned experience of the class and can make certain specific contributions.

(b) To indicate what items are to be particularly looked for. If the film-strip contains titles, enough time must be allowed for the class to read them.

(c) Main points are to be written on the board.

(d) Evaluation after a film-strip is shown, Tests may be made through oral questioning, written materials or observation of student performance. As a film-strip is shown, the teacher may stop to make comments, to answer questions or to carry on discussions provided the continuity of the film-strip is not disturbed. Sometimes the entire film-strip may be shown without any interruption and then shown a second time, thus providing opportunities for adequate discussion.

The motion picture, silent and sound, is also very helpful as a teaching aid in science. Ordinarily, the silent picture either with titles or with spoken comment by the teacher should be used in preference to sound film. A motion picture (sound) may be used for instructional purpose if the sound track offers distinct advantages. A science teacher must be familiar with the best films available in his field. For effective teaching, the teacher should give advance assignments based on what is to be seen in the film so that there may not be any doubt in the minds of the pupils regarding what they are to look for during the showing of the film. The difficult and new words that may occur in the film should be written on the black-board and these should be clearly understood by the pupils. A film in science should, if possible, be presented immediately after developing the points to be observed during the showing. After a film is shown, the teacher should start a discussion based on the items for which the pupils were to look during the presentation of the film. A science teacher should also take care to answer other questions of the pupils arising as a result of the discussion. He must also eliminate any erroneous impressions which might be created during the showing of the film. The entire film or portions of it may be shown several times, depending on the needs of the pupils. The teaching of science will be effective if the discussion held at the end of a film show may stimulate the pupils to further activity associated with the unit under consideration. Great caution should be taken by science teachers against showing any unrelated films or more than two related films during the same period as such film-showing serves only a diversion from classwork. The interest of the group of pupils is to be aroused first and the purposes for viewing the film will have to be clearly established in the minds of the pupils before the teacher thinks of presenting any film as an aid to teaching science.

By means of an opaque projector it is possible to place on a screen an enlargement of opaque materials such as pictures, charts, graphs, photographs and illustrations on postcards and those taken from books, magazines and newspapers. The science teacher may find abundant material from current and back issues of magazines and scientific journals which he may show to his pupils in an enlarged form. Besides, the images of various small materials may be projected readily on the blackboard. The opaque projector can also reproduce colour on the screen.

BROADCASTS ON SCIENTIFIC SUBJECTS

There are still relatively few science broadcasts which are suitable for secondary school children. Some times interesting science programmes are planned to help listeners understand the current scientific discoveries and thus to stimulate interest in science. The use of radio programmes provides discussions and interviews of distinguished scientists dramatisation of past and present events, such as the discovery of the battery, or incidents in the life of Newton or Fareday etc .In order to utilise the school science programme as a supplementary teaching aid, the science teacher should know the general outlines of these programmes and the advance information contained in the teachers' guide so that he may prepare the class for listening in. This preparation for the broadcast is highly desirable and the extent of such preparation is dependent upon the background of the group. Children without any background or preparation are not likely to be at all interested in the educational science broadcasts offered.

The uses of some of the audio-visual aids as discussed above are not unique to the teaching of science but they help the science teachers to a large extent in making the learning of science functional, as much of the content of science is relatively abstract and hence difficult to comprehend if only tradtional teaching methods are followed in the classroom.

THE QUANDARY OF SCIENCE IN THE ELEMENTARY SCHOOL

N. ELDRED BINGHAM

*Professor of Science Education, University of Florida**

At a time when man's knowledge doubles about every ten years, and most of this increase in knowledge is in the area of science, those responsible for the operation of our schools are in a quandary regarding the place of science in the elementary school. As J.H. Fischer of Columbia University has said, "The expansion of knowledge has made it utterly impossible for the school to deal effectively with a field, simply by trying to give the child a summary of it." He goes on to point out that pioneering is needed to give more depth to subject.

Yet how frustrating it is, on the other hand, to have so rigid a schedule of activities that children must stop their highly motivated pursuits in one area, to take up another area, because a bell rings.

The quandary of science in the elementary school seems to focus on five question: (1) Why teach science in the elementary school? (2) What science shall we teach in the elementary school? (3) Who shall teach science in the elementary school? (4) How shall we design a curriculum in elementary science to take advantage of what we know of child growth and development? (5) How can we better articulate the elementary school science program with that of junior and senior high school? Let's consider each of these separately.

WHY TEACH SCIENCE IN THE ELEMENTARY SCHOOL

Certain of the reasons for teaching science cluster around enabling all children, youth, and adults to live safely and effectively in the technological society of which they're a part. Efficient production and distribution of all goods and services involves many applications of science. Resources must be used wisely to maintain a high standard of living. And beyond this, an understanding of the nature of science, an awareness of the findings of science, and a recognition of the limitations of science are necessary if each individual is to develop what is for him rational and satisfying picture of the world. This picture has to do with his reasons for doing things, with his formulation of a way of living satisfactory to him and to his fellow men.

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*At present member of the Teachers' College Columbia University Team, Delhi.

This training in science should begin early in the elementary school, for everyone goes to the elementary school and a large portion of the population will miss science instruction unless it takes place here Second, it is the time in one's life when most individuals have a natural interest in the world around them, and thirdly, it is a time when mental habits are being formed, when boys and girls are learning to think. These boys and girls should be made to prove certain conclusions, to come to understand that the essence of science is that conclusions are arrived at on the basis of facts.

Over and above the need of the individual for science in order to live effectively in society, is the need of the individual to do his share in maintaining and advancing the society in which he lives. We need more scientists and we need to get them started earlier. These scientists need more and better background in the sciences, sometimes two years beyond the doctorate, to aid in charting the road ahead. And the various technical advances acquire a wider variety of better trained technicians than have been needed in the past.

Since the world we live in involves so much science, the decisions of the statesmen, politicians, and other national and international leaders must be based on an awareness of the role of science in society if those leaders are to effectively chart the social, economic, and political road ahead.

Finally, it is important that the man on the street have some understanding of science, because legislators never go far beyond public opinion, and public opinion should be based upon an awareness of the contributions of science to our society. Otherwise how may these legislators deal adequately with such problems as those of atomic testing, natural resources, the prevention of the extinction of many of the natural plants and animals, the extension of research, or the population explosion? We are surrounded by problems that involve scientific factors and the man on the street must be aware of them.

In spite of the vast evidence of the need for science if one is to live effectively in our society, and of the need of society to have its children educated in science, many of our citizenry and even some of our elementary principals and elementary teachers act as if they responded negatively to the quandary; 'Shall we teach science in the elementary school?'

WHAT SCIENCE SHALL WE TEACH IN THE ELEMENTARY SCHOOL?

There are many questions to consider in arriving at a satisfactory answer to this quandary Shall the science we teach be primarily concerned with the natural environment, or with the technological environment, or are both important? Is it the social use of science or is it an understanding of the nature of science that is more important? Are the needs of a society best served by teaching what is now known, or by an emphasis upon accounting for what we now observe to happen?

Shall the science we teach in the elementary school be largely descriptive or shall it be largely investigatory? Shall the content we select stem largely from interests of children, or from a recognition of important basic ideas of science on the part of the teacher and of curriculum makers? Are the needs of the future scientist the same as, or quite different than the needs of the future technician or the future businessman, or concert pianist? What are the skills and knowledges needed by the children who are now in school twenty-five years from now? Are they the same as those of today or will they be quite different from those of today? If they will be quite different from those of today then what elementary science will best fit these future citizens to live effectively in that much changed society? What kind of behaviour typifies the scientists who make an outstanding contribution to our society? To what extent is this kind of behaviour desirable in the ordinary citizen? Can this kind of behaviour be taught in our elementary schools? These and many other questions help us to illustrate the quandary regarding what science should we teach in the elementary school.

The scientific revolution, which has been going on for more than three hundred years at an ever accelerating pace, has within the past few decades moved at such a staggering rate that a revolution in science teaching became inevitable. A consequence of this rapid obsolescence of learning is that the teacher who is alert has to be continually studying, for the science he teaches changes markedly from year to year.

Elementary science followed the introduction of general science and biology in the high schools and was planned from about the same point of view as were general science and general biology. In the early 1920's general science and general biology were introduced into the secondary schools in place of the more specific disciplines, in order to make all students aware of the nature and extent of science, and to give them experience at an introductory level working the way a scientist works. Problem situations were designed to make the students speculate regarding their solutions, and plan laboratory activities to test these speculations. Efforts were made to habituate the approach of science in the solution of problems in the natural sciences, particularly those science problems that ramify widely in human welfare.

In the intervening years much of the original purpose of general science, of biology, and of elementary science, has been lost......in a frustrating effort to try and have the children informed regarding all the things that are taking place in the sciences.

However, we resolve this quandary of what science to teach in the elementary school, certainly the emphasis must be upon the very process of science—a process in which one gathers the facts and bases his conclusions on these facts, a process in which social and political and religious prejudices are reduced to a minimum as a basis for decision making. To a considerable extent the activities in the elementary school should be concerned with the development of concepts, and conceptual schemes to account for what happens. Reason is used in predicting what will happen under certain conditions, and also in accounting for what happens Experiments are used to get the facts to verify or to reject the predictions. This is the way the scientist works. Bacon said regarding this matter, "Reason does not make the conclusion certain unless the mind discover it by the path of experience." Newton said, "I shall not minigle conjectures with cetrainties." Elementary children should have experience in gathering facts and experience in reasoning from these facts. They should learn to distinguish facts from the explanations of the facts they have gathered. One of the best ways to help them distinguish facts from the explanation of facts is to involve boys and girls in experiments ; in quantitative experiments in which they collect data, make graphs of the data, and then use the graphs in developing concepts. In this way both mathematics and science can come to function more effectively in their lives, and they will move in the direction of describing nature in terms of quantitative data. In this respect they will be more like the scientists who are charting our destiny.

WHO SHALL TEACH THE ELEMENTARY SCIENCE ?

One can teach what one does't know as well as one can return from a place one hasn't been. This statement, not original with me, serves to point up our thinking regarding who shall teach science in the elementary school, and it is related to what science one teaches in the elementary school. It is a far more serious matter to be uniformed regarding the basic ideas of science than it is regarding the fleeting applications of technology in our immediate environment. A teacher cannot hope to know all of the technology, but it is shameful if she is not informed regarding the truly significant ideas of science, for these ideas enable her to weigh questions presented by students and to select content of importance in guiding the development of the young minds that are her responsibility.

In America we are committed to the self-contained classroom. It permits a flexible scheduling, it makes possible a close relationship between the teacher and the child ; it is like a home away from home. With experienced teachers who have excellent backgrounds, who understand how children grow and develop and learn, this kind of arrangement is quite ideal, and even though the teacher may not have an excellent background in science, if the library has excellent encyclopedias and trade books in science to supplement the rather limited elementary science texts, and if she goes along with children and helps them plan activites to test ideas, plan experiments to illustrate ideas, and the like, she is in a position to make "the way of science" an integral part of almost every activity. This teacher can use his group's interest in science, or in almost anything else, as a means of moving along in the other areas of living. Reading may become purposeful, arithmetic is useful in quantitizing experiments, pictures are painted to illustrate ideas. Maximum learning occurs when it is timed to coincide with a child's desire to investigate something, with his curiosity, and this close interaction between the teacher and the child is something precious to preserve. Questions may be considered at the time when they develop, and these questions may serve as a stimulation to problem-solving, "research activities," in the library and in the science corner.

But it is an almost impossible task to staff our elementary schools with a complete complement of teachers who can adequately serve the needs of the children in science. Science is one of those fields where if a person is to be competent he must have some understanding of all of the sciences, for the questions of elementary children are not confined to a particular discipline. Some of the questions of children must be inadequately treated or even suppressed if the teacher does not have a speaking acquaintance with all of the sciences, and sufficient experience in one or more of them to have developed a feeling for the nature of science. Certainly an elementary teacher, to deal effectively with many of the questions, needs a background of college courses in biology, geology, astronomy, mathematics and in the physical sciences.

This background cannot be provided in the preparation of all elementary school teachers. Science must become one of those fields, like music or art, that will be at least partially taught by specialists in the elementary school. There should be a room set aside for this science teacher, for the science teacher cannot carry much of the equipment she would wish to use in teaching from room to room. Consequently there should be a room where she may set up permanent aquaria and other demonstrations that may be used in teaching science. This room may serve as a resource room for equipment, reading materials and the like, to be taken by students and teachers back to their largely self-contained classrooms. At carefully scheduled times, worked out cooperatively by the teachers and the science specialist, classes should spend time working in this science room under the direction of the science specialist. Here the curriculum may be directed toward basic ideas of science. It is possible, in the educational system in America, to provide science specialists to be placed in every elementry school, while it is not possible to adequately prepare all elementary school teachers to deal effectively with science. The work of the science specialist would supplement the science work of the classroom teacher, and meet the needs of those children who need to go far beyond the training and background that is possible for all elementary teachers.

How Shall We Design a Curriculum in Elementary Science to Take Advantage of What We know of Child Growth and Development ?

Children are primitive scientists at heart. They are curious until perhaps they find no one interested in their queries. They are explorers and they are adventurers Many are keen observers, and others can be helped to observe. It is amazing how much more young children grasp if an adult reacts to their apparent interest, how much more rapidly they learn to speak a languge, how quickly they begin to develop concepts of hot, of hurt, of dog, and the like. They are collectors of natural life, too. If they are helped in their observations, there is a basis for increasing rather than squelching their reactions to the many stimuli that surround them.

A teacher may capitalize on these curiosities, these interests. She may discover children's interests or she may awaken new interests, then she may help them to develop those interests. A teacher may discover her children's interests by getting them to talking, and listening to what they say, or by observing what they seem to be curious about, or by asking probing questions and then paying attention to their responses. A teacher may awaken an interest in students in something that she believes important for them to learn or to investigate by providing some kind of an enriching experience out of which questions and projects may arise. A teacher might do an interesting experiment, or she might read and discuss some recent research report in the Science World or the Scientific American, or she might provide an interesting film or speaker. There are many stimuli that may be used to extend the observations that children make. And then through interaction with the children the teacher may raise questions that will be guides to further study.

What kinds of questions will stimulate the children to go further ? There are two kinds. One kind pushes the child to a point where he knows he does not know the answer, and feels a need to investigate, a need to get more adequate date to be sure about something. The second kind pushes the child to the point where he realizes that two things he believes conflict, or disagree ; are disharmonious ; that both cannot be true. This is the most productive kind of question, and out of it some interesting investigations should develop. Some things a teacher may do to stimulate his children to investigate are : (a) Suggest alternative explanations to account for the phenomena, (b) Predict the consequences of alternative explanations in various situations, (c) Mentally explore related past experiences, (d) Construct models, perhaps mental images, to visualize the situation, (e) Do experiments to test predicted consequences, (f) Apply the tests of adequacy and of harmony to the predicted consequences, and (g) Accept or reject explanations in the light of the tests of adequacy and of harmony. Is there adequate data available for drawing the conclusion ? Under what conditions is the conclusion to be considered valid ? Is it in keeping with explanations that may be used to account for a number of happenings ? Scientists prefer the simplest explanations which accout for the widest number of observable phenomena in a harmonious manner.

To capitalize to a maximum extent on the curiosity and interests of children, there should be a wealth of supplemental materials, such a library books which may be used to verify children's conjectures and as sources of new queries to be undertaken. There should be an opportunity to use some of the tools of the scientist to experiment, to study the small as well as the large, to weigh and measure to construct illustrative models, to test hypotheses at different [illegible] to create different conditions for living things and observe [illegible] over a considerable period of time. There should be a place [illegible] where children can actively try out their ideas. This can be done to a greater extent in the science room than in the individual self-contained classroom, [illegible] but the activity is appropriate for both.

And if the process of arriving at sound conclusions based on adequate data is to be practiced, the children must share in determining what it is that they're going to investigate, how they will investigate whatever it is and in making or setting up the apparatus that they're going to use to test their ideas.

As teachers of science we can no longer be satisfied with teaching the names of things; with merely classifying them, with limiting the [illegible] to the how and what stages of thinking. Rather, we must devise ways of involving the children in making careful observations in exploration, in collecting data, in checking on the adequacy of the data, in thikging about the conditions under which the data apply, in gaining a real understanding of what takes place, and in developing dependable concepts. And this must occur at every age level. As the children progress through the elementary school they can develop a more precise, a more complete, a more quantitative explanation of what it is they see around them.

The curriculum in elementary science may be designed to take advantage of what we know about child growth and development by building upon the natural interests and curiosities of the children in the things about them, and then by guiding them in their investigations in the library, in the laboratory, in the field, or wherever they may be.

How Can Teachers Better Articulate the Elementary School Science Programme With That of the Junior and Senior High School?

Perhaps paramount in this articulation is to early take on the way of the scientist. The more dependable concepts a child develops, the more he is concerned with checking these concepts against other concepts that he holds; the better the quality of the conceptual schemes he will build to guide his life. This is a far different matter than being primarily concerned about the myriad of technological applications that barrage the child in his daily experiences. He can learn to cut through this technical barrage to the basics because he has learned to judge the soundness of ideas and the worthwhileness of ideas. He has developed ideas that explain a wide number of related phenomena.

Several projects are currently being carried on to see how these ideas with "mileage" may be developed. In the Illinois Elementary School Study directed by Myron Atkin, children are faced with some of the problems that faced the early astronomers rather than with a cataloging of the facts now known about the solar system. In the first of a series of books that they have produced entitled "Charting the Universe," two ideas are richly developed by many experiments. (1) How do we measure distances in space by parallax? and (2) How do we use the intensity of light as a measure of distance?

Robert Karplus, of the Department of Physics at the University of California in Berkeley, in an elementary science experiment that he has been carrying out points out that "the present content of science consists of the concepts and relationships that mankind has abstracted from the observation of natural phenomena over the centuries. It represents the outcome of a long and slow process. During their elementary school years boys and girls are engaged in precisely this kind of abstracting process with respect to their own natural environments. The function of education is to guide the development by providing them with particularly informative and suggestive experiences as a base for their abstractions At the same time, and this point is often overlooked, they must be provided with a conceptual framework that permits them to perceive the phenomena in a meaningful way and to integrate their inference into generalizations of lasting valve" This project also focuses on the construction of a conceptual framework for the science curriculum.

We can better articulate the elementary school science program with that of the junior and senior high school if from the very beginning we make children aware of the nature of science, if we help them live as scientists.

In the early grades teachers may help pupils become acquainted with the different kinds of things of natural interest to children. This is the way science began. It started out as natural history, and later became increasingly experimental. What is in the environment? What are the things made of? Where do they come from? What makes rocks hard? How is soil formed? What makes it rain? Why does the wind blow? Why is it light during the day and dark at night? How are shadows formed? How do plants grow? How should I feed and care for my animals? How do they raise their young? Why do they behave as they do? These and a myriad of other questions can serve as the basis for many investigations. The first impressions will be largely descriptive and later more quantitative. Experiments are a means of getting more precise observations on which to build more definite and dependable concepts. In a child's first thinking about science, he is very dependent on direct experience, but as he progresses through the elementary school he is able to an increasing extent to focus his thoughts on relationships between abstractions without constant reference to a particular situation.

On a sound elementary program such as I've described, there could be built a junior high program that would emphasize the biological sciences at the 7th grade, the earth sciences at the 8th grade, and at the 9th grade the physical sciences, particularly physics and chemistry. It is quite important that at the 9th grade level those who are going on to the senior high school have a grasp of the basic ideas of physics and chemistry, so that the biology at the 10th grade may be something more than descriptive biology, may be more representative of what it is that biologists are concerned with today. What distinguishes living from non-living things? What relationships exist between various kinds of living things and between living things and the physical environment? What are the requirements of life? What are the limitations on life? How did life develop? How does life reproduce itself?

In the upper years of the senior high school there is a place for beginning courses in physics and chemistry that deal with the subjects in an experimental and quantitative way, and the work in the subjects of biology and chemistry and physics in the senior high school can thus be at a much higher level than heretofore, a level comparable to beginning college courses in these subjects. In this way, it is possible to speed up the training of those who will go on in the sciences, for by means of special examinations many of these would qualify for advanced placement when they reach college.

The quandary of science in the elementary school has been discussed under five different queries. A case has been made that to live effectively in our technological society every individual needs to know some science, and that science is important for maintaining and advancing our society; that the emphasis in the science programme should be on informative, suggestive experiences which form a base for sound concepts and conceptual schemes; that a science specialist is essential to help primary teachers teach science and to teach much of the science of the intermediate grades; that the science curriculum of the elementary school should be based upon the natural curiosities and interests of children, that the teacher may help in developing these interests by stressing participation of the children in all of the investigatory activities and in applying the tests of adequacy and of harmony to the predictions and conclusions they have made; that a well articulated programme could be built by emphasizing the natural and the physical sciences, as explained above, in the elementary grades, by stressing the biological sciences at the 7th grade, the earth sciences at the 8th grade, and the physical sciences at the 9th. Then on the basis of a sound background in the natural and physical sciences, the disciplines of biology, chemistry and physics might be taught in the senior high school at a level far exceeding than presently found in most schools. In this way we can improve the quality of science instruction of the future citizens of America, and speed the training of those who will become our future scientists.

CLASSROOM EXPERIMENTS

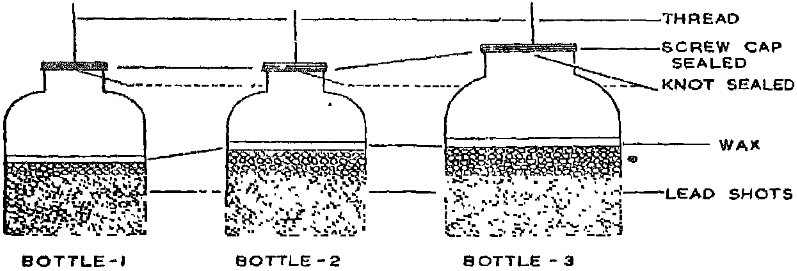
P. S. V. RAO

B. E. M. High School, Mangalore

PRINCIPLES OF ARCHIMEDES

APPARATUS :

Three bottles are got ready as shown in the sketches. Two bottles are of the same size. The third bottle is of a bigger size. The first two bottles are made to weigh 100 gms and 150 gms respectively by adding lead shots and pouring paraffin wax to keep the shots in place. The volume of the two bottles used is 70 cc each. The third bottle is made to weigh 150 gms. Its volume is 100 c. c. For weighing a spring balance is used. The bottles are numbered 1, 2 and 3 with red nail polish.



METHOD

The weight and volume of each of the bottle are found out at the commencement of the experiment.

Experiment 1

Now Bottle 1 is taken. It is suspended from the spring balance. The weight of the bottle is noted. A beaker of water is brought under the bottle. Then it is slowly immersed in water. The pupils are made to observes, the bottle apparently losing weight. When the bottle is completely under water they notice that there is no further loss of weight. The bottle is again withdrawn from the water. The spring balance now reads the original weight of the bottle.

Experiment 2.

The above experiment is repeated by using kerosene oil

Conclusion

When a body is immersed in a liquid it suffers an apparent loss of weight

Experiment 3.

Now bottles Nos. 1 & 2 are taken. Both of them are weighed in air and in water and the results are noted

Bottle No.	Wt. in air	Wt. in water	Loss of Wt
1.	100 gms.	30 gms	70 gms
2.	150 gms.	80 gms.	70 gms.

Conclusion

The apparent loss of weight does not depend upon the weight of the object

Experiment 4.

Now, bottles 2 and 3 are taken and the above experiment is repeated. The results are noted as below :-

Bottle No.	Wt. in air	Wt. in water	Apparent loss of Wt
2.	150 gms.	80 gms.	70 gms
3.	150 gms.	50 gms.	100 gms

Conclusion

The apparent loss of weight suffered by a body depends upon its volume.

Experiment 5.

Now all the three bottles are taken and weighed in Kerosene oil and results are tabulated as below.

Bottle No	Wt. in air	Wt. in Kerosene oil	Apparent loss of Wt.
1.	100 gms.	44 gms.	56 gms
2.	150 gms.	94 gms.	56 gms.
3.	150 gms.	70 gms.	80 gms.

Conclusion :

The apparent loss of weight suffered by a body depends upon the density of the liquid in which it is immersed.

These experiments can be used now to draw the conclusion that when a body is immersed in a liquid the apparent loss of weight suffered depends upon the volume of the solid and the density of the liquid.

Experiment 6.

All the bottles are first weighed in air and then in water and the results tabulated as below :—

Density of water is taken to be 1 gm/cc (d)

Bottle	Wt. in air	Wt. in water	Loss of wt.	Volume of water displaced	v x d
1.	100 gms.	30 gms.	70 gms.	70 c. c.	70 x 1=70 gm.
2.	150 ,,	80 ,,	70 ,,	70 c. c.	70 x 1=70 gm.
3.	150 ,,	50 ,,	100 ,,	100 c. c.	100 x 1=100 gm.

Conclusion

The apparent loss of wt. it equal to the volume of solid when the density of the liquid is one.

Experiment 7.

The above experiment is repeated using Kerosene oil. The density of the oil is found out. Here it has been taken as 0.8 gm/cc.

Bottle	Wt. in air	Wt. in Kerosene	Loss of wt.	Volume of Kerosene displaced	v x d
1.	100 gms.	44 gms.	56 gms.	70 c. c.	70 x 0. 8=56 gms.
2.	150 gms.	94 gms.	56 gms.	70 c. c.	70 x 0.8=56 gms.
3.	150 gms.	70 gms.	80 gms.	100 c. c.	100 x 0.8=80 gms.

Conclusion

When a solid is completely immersed in a liquid Apparent loss of weight=volume of the solid × Density of the liquid

The Unit Approach To Teaching Science

by

Dr. And Mrs N. Eldred Bingham

How shall science experiences for boys and girls be selected? How shall they be initiated? How shall they be organized? How shall the experiences be related to other school activities? How can the outcomes of these science experiences be related to the life needs of the students? In every teaching situation the teacher must play a major role in determining what to teach, how to teach and the relationship of what he teaches to other school activities and to the life needs of the student. The unit approach is one of the most effective ways to teach. An experienced teacher, who possesses a wealth of information on the subject to be taught, and who understands how children learn, can built a unit with the students. This is perhaps the most effective way to teach. Less experienced teachers, with less complete grasp of the content to be taught, can improve their teaching by planning units ahead of time, and by using these units in the classroom. He may even adapt units prepared by others. Whether the unit is to be planned with the students, or to be planned ahead of time, there are certain elements that should always be considered. In this account we propose to show how a teacher may plan a unit with her students and then to present an outline to be used in preparing units.

Building a unit with students :

Psychologists tell us that students must have many experiences while learning before the ideas are meaningful to them as learners. How will they get these experiences? A normal unit approach may well start with the class and the teacher identifying some significant questions, followed by the teacher and the students selecting some problem for study. They may ask by what means will the problems be solved, with what materials, and how shall the results be evaluated? Then should follow a variety of experiences well-chosen to meet specific objectives. There should be opportunity for wide reading and finally a pooling of findings by pupils and teacher alike with an evaluation of the total experience. Motivation for the unit approach to teaching science should be easy if a teacher begins with pupil interests and questions. When pupils open any problem area for inquiry, they usually begin with a series of questions which pose different parts of the total problem. They may not have the scientific vocabulary to state the problem fully, but all important is the fact that they are curious. They have asked questions, and you as their teacher have the opportunity to help channel their questions into a larger problem which if solved, becomes the basis for developing understandings and generalizations. What a great responsibility a teacher has !

The organisation for a unit approach must be carefully considered by the teacher. It is he who writes their questions in terms of larger problems to be solved. Then he must make an array of activities and experiences to be used in answering the questions. Only those activities specifically applicable should be considered. Both short-time and long-time projects may develop. Available resources should be utilized, such as films, film strips, radio programs, field trips, and the use of experts in the field as resource people. In evaluations such questions may well be asked. Do students maintain a natural interest in the study ? Do they employ good thinking in the work ? Do they report matters accurately ? Do they utilize previously learned knowledge ? Do they arrive at generalizations from their experiences and do they apply these generalizations in new situations ?

Usually some high-interest level final activity results from a unit study. It may be showing to parents some of the results of the study. Perhaps a play is written and acted about the endeavour. The projects could be exhibited at a science fair.

A unit approach as described above should be an adventure for both the teacher and the students where both learn. One has only to try it to find that numerous reading, writing, and arithmetic skills are constantly, used. Much subject matter is learned, not as an accumulation of discrete facts, but in a setting of meaningful experiences from which can be developed understandings.

OUTLINE FOR THE PREPARATION OF AN INSTRUCTIONAL UNIT

I. *Introduction* :

Write two or three approaches to use in creating and deepening an interest in studying the topic. These approaches are to be enriching experiences out of which questions and problems arise.

II. *Questions and Problems* :

State here the major questions to be answered and the problems to be solved. Suggest from six to twelve—not more. In some cases list two or three sub-questions. Number these main questions 1, 2, 3, and so on. Then number the corresponding parts of III and IV below accordingly.

III. *Activities and Experiments* :

Array the activities and experiments to be used in answering the questions and in solving the problems listed in II above. Include only activities specifically appropriate. Do not waste time or space making general statements such as, "show a film," or "take a field trip." Number your activities and experiments as in II above.

IV. *Content* :

State here the answers to the questions and the solutions to the problems presented in II above. This section should consist of clear-cut, definite, declarative statements of the outcomes of instruction. These statements are the concepts you hope the students will learn in the study of the questions and problems. These concepts should be numbered as in II and III above for easy reference.

V. *Culminating Activities* :

The purpose of a culminating activity is to provide some experience in which the students will re-organize the results of their study and so gain a new level of understanding. It is also to develop an appreciation for the area that has been studied. Any good unit should suggest at least two culminating activities that might be used to deepen an understanding of the material considered in the unit and to develop an appreciation for this content as it relates to other content and to their lives. An original play may be presented. A demonstration type assembly program may be presented. A special field trip may be planned. Resource persons may be told of the findings and then asked to react by sharing their wisdom regarding the matter with the class.

VI. *New Questions* :

Several questions that can logically be expected to arise out of a study of the unit should be presented here. This is very important in avoiding the error of assuming that science is fixed—something to be memorized and learned exactly as presented. It gives the students experience acting as a scientist acts. When a scientist solves one problem he finds others which he wishes to solve in connection with his researches. This raising of new questions enables the students to see that science is a quest for knowledge in which new insights arise out of past experiences.

VII. *Relationship to Other School Work* :

Stating one or two ways that the work of this unit is related to other school work helps the teacher make his teaching more functional. This in turn helps the students gain a better command of their environment—and so they become more self-reliant.

VII. *Resources* :

List here the resources that may be used in teaching this unit. These suggestions must be specific for this particular unit. They may include reference books for teachers, reference books for students, magazine articles, special films or film strips, special field trips and the names of people or institutions that may be called upon for help.

This article has given suggestions for building a unit with students and for writing a unit prior to teaching. The writing ahead of time is an excellent way for a teacher to prepare for unit teaching. A teacher may take a unit prepared by someone else and in his planning adapt the unit to his particular teaching situation. Organizing to teach along the lines suggested in this article is an effective means for a teacher to improve his grasp of subject matter to be taught and his ability to help his students gain an understanding, for the very process of organization eliminates much that is irrevelant, and emphasizes what is of most worth.

PLAN OF A TEACHING UNIT

N. K. SANYAL
Field Adviser, DEPSE

Planning a teaching unit is one of the most important and necessary jobs for any classroom teacher. The organization of a teaching unit needs a lot of careful planning, logical development of ideas and making use of students in purposeful activities. It must provide for flexibility and variation in procedures. It should provide for maximum learnings and appreciations so that it can be used for improvement of teaching. It should develop a scientific approach to the study of science on the part of the students and teachers.

Based on the Unit Approach to Teaching Science, an actual outline of a Teaching Unit for class VI is suggested below. It must however be understood that this should not become a rigid frame for all units. There may be flexibility and variation as and when needed

Topic - **Heat and how it affects things**
(Level Class VI)

I. Introduction

A. Experiments :

Burn a piece of paper by focussing sun rays on it by a convex lens.

Show the bursting of a balloon filled with air when kept near a fire or source of heat.

B. Discuss the preliminary experiences and possible causes like some of the following to ensure pupil participation :—

(a) Why one feels cold on a cloudy day in winter ?
(b) Why do you not touch glowing embers ?
(c) Why is coal required to drive a railway engine ?
(d) How do we get fire for cooking ?
(e) Why does the shade of tree offer coolness on a summer day ?
(f) How do we know if one has fever ?
(g) How do we know whether it is warmer or cooler than yesterday or some other day ?
(h) Why is a clinical thermometer jerked before use ?

II. *Questions and Problems.*

Some of the major problems and questions which remain to be answered are :—

1. What is heat ?
2. What are the sources for heat ?
3. How does heat affect things ?
    - A. What is hotness or temperature ?
    - B. How does it change volumes of things ?
    - C. How does it change solids to liquids or liquids to gases or vice-versa.
4. How is temperature measured ? What does a thermometer do ?
5. How do different thermometers measure temperature ?
    - A. What does a thermometer measure ?
    - B. What are the different scales of thermometers ?
    - C. What are fixed points ?
    - D. Why do we use a clinical thermometer to measure body temperature ?

III. *Activities and Experiments to be used in answering questions and solving problems.*

1. *Heat is a form of energy—It has no weight*

(i) Carefully counterpoise a hot metallic bob on the hook of a balance. Demonstrate that the balance remains counterpoised even after the bob gets cooled.

(ii) Deduce that heat is not matter since it has no weight. It can do work as illustrated by burning of coal in a locomotive engine or petrol in an automobile.

2 *Heat comes from many sources*

(i) Recall previous experiences of pupils regarding heat obtained from fuel, sun or electric heater etc.
Heat a metal rod red hot on fire. Why should it not be touched ?

(ii) Make children rub their palms and feel the warmth caused Rub a piece of stone on the floor and make children feel. Recall experiences of hot flour from grinding wheat in mills and other similar examples.

(iii) Let children feel the warmth of a glowing electric bulb or the warmth of a wire connected to two terminals of a cell for a while. Recall experiences of electric heater, stove or radiators etc

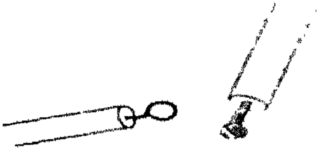
(v) Add carefully a few drops of concentrated sulphuric acid in a beaker of water. Let the children feel the difference of temperature by touching the side of the beaker before and after.

(vi) Concentrate the sun-rays by a convex lens or concave mirror on the palm of a few students to feel the heat of the sun-rays.

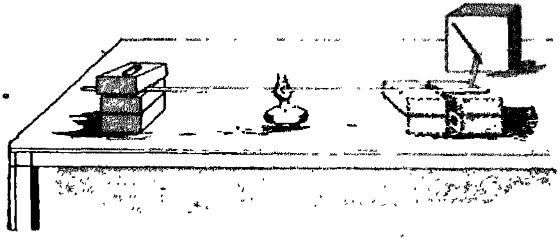
3. *How does heat affect things*

A. *Heat expands solids, liquids and gases*

(a) Demonstrate Ring and Ball experiments or ring and plug experiment (Unesco Source Book P. 131).

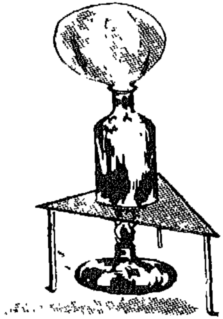


(b) Fix one end of a metal bar or strip on a block of wood. Keep the other end on a pencil kept on another block of wood. To the edge of the pencil fix a straw or pin to act as a pointer. Heat the bar in the middle (between the two blocks) and make children explain why the pointer moves and in what direction ? (Unesco Source Book P. 131).



(c) Fill coloured water in a bottle or flask fitted with a cork and a long glass tube in the cork. Keep the flask in a pail of hot water. Why does the water rise ? Demonstrate with several liquids. (Observe and explain the initial drop of level and then continuous rise of liquid level) (Unesco Source Book P. 132).

(d) Recall the bursting of a balloon earlier demonstrated. Fix a balloon on the mouth of a large bottle or flask. Warm the flask carefully and observe the balloon. What happens on cooling ?



(e) Show escape of air bubbles from a flask fitted with a cork and a piece of glass tubing, the open end of which is dipped in water, when it is warmed (Unesco Source Book P. 132).

(f) Recall applications of expansion and contraction and discuss the causes of :

- (i) Space left between rails.
- (ii) Fixing metal tyres on wooden cart wheels.
- (iii) Space left at the end of girders of bridges and buildings.
- (iv) Sagging and contraction of telegraph wires in summer and winter respectively.
- (v) Bursting of cycle tubes on summer days.
- (vi) Opening of lightly corked bottle by warming.
- (vii) Why phials and bottles are kept partially filled.
- (viii) Expansion and contraction of liquids in thermometers.

B. *Heat causes rise in temperature.*

(a) First feel a flask or vessel with cold water. Warm it over a fire for a while and feel the difference. Addition of heat has caused it to become warmer.

(b) Heat a ball of metal on a fire. Do not touch but allow children to feel its warmth from a slight distance. Then plunge it in a small vessel containing some water. Is the metal ball still hot ? What has made the water warmer ? (Addition of heat) What has made the metal cooler ? (Loss of Heat), Discuss the changes to develop the concept that a change in temperature is caused by passage of heat to and from a body till the two have the same temperature.

Recall experiences of children regarding use of ice to cool "sherbat" or drinks. Which gains heat or loses heat?

C. *Heat causes change of State*

(a) Recall familiar examples of melting of ice, coconut oil or ghee in summer, melting of wax on warming or evaporation of water on boiling.
(b) Heat a piece of ice on a dish and observe the change of state. Further heat to show change from liquid to gaseous state.
(c) Cool some molten wax in a vessel containing water to see change from liquid to solid on cooling.
(d) Allow some steam to condense from the spout of a kettle on the sides of a vessel filled with cold water. Why is water collected on the sides? Where does it come from? What change of state has taken place?
(e) Recall experiences, if any, of manufacture of ice cream or "Kulfi malai", of molten iron from foundries, distillation apparatus etc.

4. *Thermometers measure temperature*

(a) Show that skin or sense of touch is not reliable in measuring temperature by dipping one hand in warm water, other hand in cold water for some time and then dipping both hands in the same pail of luke warm water.
(d) Examine a thermometer - Its bulb, stem, bore and graduations.
Dip the thermometer in a beaker of cold water and observe the rise of mercury when the beaker is slowly warmed. Let pupils read the temperature and understand that higher the rise, larger is the expansion of mercury because of greater rise of temperature and vice-versa.
(c) Let pupils realise the value of the smallest division in degrees (2°, 1°, .5 or .2° as the thermometer may indicate).

5. *How do different thermometers measure temperature?*

A. What does the thermometer measure?

(i) Take two vessels of equal size containing unequal amounts of water (one say about 50 gms. and other say about 250 gms) Measure temperature of both. Add to each an equal amout of hot water at the same temperature and record the temperature of mixture in two cases? What is the amount of heat supplied in each case? Why the thermometers record different temperatures?

(ii) Heat a small metal ball to redness and plunge it in a big pail of water whose temperature has been noted before. Note the rise of temperature then heat the same ball to a temperature of say 100° and plunge it in a small glass of water to note similarly the rise of temperature in this case. Which shows greater rise and why?

B & C

(i) Show Centigrade and Fahrenheit thermometers and let pupils compare the scales. Let them draw the scales on their note books.

(ii) Record temperature by both the types of thermometers when kept in melting ice and in steam. Explain why these temperature points in scale are called fixed points.

(iii) Measure temperatures of human body, tap water, air, hot tea etc. separately by each thermometer.

D—

(i) Let children examine the readings in a clinical thermometer and observe any peculiar features about the bore and graduation.

(ii) Let the bulb of an ordinary thermometer be placed in the mouth of a child (or under the arm pit) and after half a minute let the reading be taken by another child while it is still there then take it out and again note the temperature after a few moments. What is indicated?

(iii) First plunge the bulb of a clinical thermometer in some tepid water at a temperature of say 104°F. Then without jerking it note the temperature and dip it in cold water. Does it show any change of temperature?

Then without jerking it use it for finding the body temperature of a child and see if there is any change of temperature.

Finally jerk the thermometer each time before recording the temperature of cold water and the body temperature. Why there is a difference now?

Let the pupils note the mercury thread carefully before and after jerking. Let the pupils also note that the scale used is Fahrenheit.

IV. *Answers to questions and solution of problems:—concepts*

	Functional knowledge of facts, concepts & principles.	Development of skills	Development of appreciations & interest
1.	(i) Heat is a kind of energy. (ii) It has no weight.	Setting experiment to test hypothesis	Making a model of steam turbine

	(iii) All molecules in matter are in a state of motion which increases as heat is added.		(Unesco Source Book P. 141)
	(iv) Heat can be made to work		
2	Heat comes from: (i) sun (ii) burning fuels (iii) chemical action (iv) electricity (v) friction.	-do-	Sun as the ultimate source of all energy
3.	Heat causes changes of (i) Temperature (ii) Volume (iii) State	-do-	Understanding applications of expansion and contraction in every-day life. Make hot air balloons
4.	(i) Temperature indicates direction of flow of heat.	Reading of a thermometer	Skin or sense of touch is no good judge of temperature
	(ii) Bodies at higher temperature must loose heat to other bodies at lower temperature till both have same temperature.	Understanding a scale or the least count	Sense of cold is merely a loss of heat from the body. Making Air thermometer (Galileo's type) (Unesco Source Book P. 133)
	(iii) The expansion of a liquid in a closed tube can be used to measure temperature.		Making an improvised thermometer.
5.	(i) Thermometers have different scale centigrade and Fahrenheit.	Handling a thermometer	Record temperature of air daily as part of weather observation.
	(ii) All thermometers need fixed points to make a scale.	Reading the temperature of different substances.	
	(iii) Temperature of melting ice and boiling water are used as fixed points.		

(iv) A degree of Centigrade Scale denotes greater range of temperature than Fahrenheit.		Making and calibrating a thermometer.
(v) The clinical thermometer is a special kind of thermometer using Fahrenheit scale.	Handling properly and reading accurately the temperature of human body.	Keeping a graphical record of fever during illness of any family member.

V. *Culminating activities*

1. A dramatic activity can be organized in which pupils are assembled, spaced in a solid square and moving to and fro one step in any direction to resemble a solid substance.

Then with the command of the teacher or by sound of a music it may be assumed that more heat is added to the body (of students). As a consequence each moves two steps in each direction To make room the pupils stand a few steps apart but retain the solid square shape. (This may represent the solid state with fixed shape and volume and its expansion by heat)

Again with another command or the sound of music the pupils move further away not necessarily retaining the solid square shape but all within each others reach and move more quickly. (This may represent change to a liquid state with definite volume, more mobile and with greater energy).

Finally with further music or command the pupils may scatter in any direction and move any number of steps more quickly. (This represents the gaseous state with no fixed shape and volume and the greatest energy).

By a series of orders the reverse type of movements may be done to explain the three kinds of changes brought by addition or removal of heat

By a series of orders the reverse type of movements may be done to explain the three kinds of changes brought by addition or removal of heat.

2. A visit to an ice-factory, distillery, iron foundry may be organized.
3. A weather record observatory could be developed, and comparison of temperature of the town with other cities reported in newspapers could be made.

VI. *New Questions*

1. Let pupils find why ice (colder than water) floats on it?
2. Why is mercury commonly used in making thermometers?

3. Why thermometers for measuring weather use alcohol?
4. Why is salt added to ice when making ice-cream or "Kulfi malai"?
5. Why in extreme summers it is difficult to record fever?
6. Why does not ice kept covered with jute or blanket melt easily?
7. Why does the wooden handle of a spade not appear cold though the metal blade does, though both are at the same temperature?

VII. *Relationship with other school work*

1. Relate with teaching of weather in Geography.
2. Relate mathematics with conversion of scales and drawing of graphs of temperature changes of the town.
3. Relate teaching of craft with making of models connected with the topics.

VIII. *Resources:*

Unesco	Source Book of Science Teaching	Ch. XIII
Lemming	Science Experiments 6.	Ch. IX
Blough & Hugget	Elementary School Science & How to teach it	Part IX
Frasier & Others	Singer Series Science Experiments.	Pp. 225-241
Marburger & Holfman	Physics of our Times	Pp. 165-216
N. S. T. A.	Science Teaching Today-Fuels and Fire	Vol. III

Some Suggested Films:—

1. Engines & Fuels—The Two Stroke Engine (Burmah-Shell) 28 mins.
2. Nature of Energy (Coronet) 10 mins.
3. Fuels and Heat (E.B.F.) 11 mins.

Science Abroad

SCIENCE EDUCATION IN THE SOVIET SCHOOL

RAJA ROY SINGH*

Ministry of Education, Government of India, New Delhi

Formal education of the Soviet child begins at the age of seven and is compulsory for the first eight classes. Children who have passed their seventh birthday, on or before September 1, are admitted to the first grade. Education at all stages is free and co-educational.

The basic structure of a school of general education is 11 years (10 years till the reorganisation of 1958). It contains all classes from I to X (now to be extended to XI) in one establishment and under a single administrative control. An 8-year school is an 'incomplete secondary school', even though it is the terminal point of the period of universal compulsory education and functions as a single establishment covering all classes from I to VIII. The remote and sparsely inhabited areas are served by 4-year schools containing the primary grades I to IV. From the point of view of structure, there are, therefore, three types of schools of general education—4-year schools, 8-year schools, and complete secondary schools. The curriculum is conceived as a whole for a complete secondary school, but there is a distinct division between class VIII and class IX, marking out the 1—8 year programme as a self-sufficient unit. The division between class IV and class V, however, is no more than a natural gradation from one class to another. Though the Soviet pedagogical literature refers to 'primary stage of education' and 'primary grades,' in practice 11 plus or 12 plus is not looked upon as a sharply dividing line between two phases of the child's mental growth. With the acceptance of a unified school as the basic pattern, merely structural changes have been very much less in the USSR than elsewhere. This 'structural' stability in a period of rapid expansion has been a distinct advantage.

The school year throughout the country commences on September 1. The school year for classes I to VIII is divided into four terms, and for classes IX to XI into two semesters. There are six full working days in a week, and 34 working weeks in a year for classes I to III and 35 weeks for other classes.

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* Shri Raja Roy Singh, Joint Educational Adviser, led a delegation of Indian Educators to the U. S. S. R. during the fall of 1961. This article is adapted from his report *Education in the Soviet Union*, Government of India, 1962.

CURRICULUM

The curriculum is substantially uniform throughout the country. The points where variations are permissible to suit local conditions are specifically indicated.

Boys and girls follow the same curriculum. All subjects are compulsory and there are no optionals. The curriculum is an attempt to determine for different stages of development, the essential body of knowledge and skills that the school must offer in order that meaningful learning may be promoted. Knowledge according to Soviet view, is a system and represents the unification of thought and practice. Meaningful learning can therefore take place only through a systematic acquisition of systematic knowledge. The curriculum is structured to reflect this basic concept.

While the curriculum is designed to set forth clearly the skills and knowledge which should be acquired by the pupils at different stages, it is conceived as a whole covering the complete secondary school from class I to class XI. This enables a close articulation to be achieved between different 'cycles' of the curriculum. The 'unified curriculum' is thus not only a curriculum offering the same essential body of knowledge and skills but also one which ensures a proper graduation vertically.

EDUCATION IN THE PRIMARY GRADES

At the primary stage the main objectives of classroom instruction are defined as equipping the child with elementary literacy in the fields of reading, writing and arithmetic—teaching the child to read *well,* to write *correctly,* to handle the four arithmetical functions and solve simple problems, creating an elementary understanding of nature, of social phenomena, and of the achievements of the Soviet people, developing thought and speech, preparing the children for later mastery of the fundamentals of science and psychologically orienting them to love of labour.

In classes I to IV the basic subjects are, Russian language, Arithmetic, History and Nature Study (introduced in class IV), Drawing, Music and Singing, Physical Culture, Craft work and socially useful work (introduced in class III). In the schools of the national republics (non-Russian language areas), the native language takes the place of Russian as the first language and Russian is introduced as second language in class II.

The allocation of time in Russian language schools in these four classes is shown in table 1.

TABLE I

Allocation of Time in Classes I—IV

					Total per week
Total No. of School hours per week	24	24	26	29	103
Class	I	II	III	IV	
Subject :					
Russian language	12	12	12	10	46
Arithmetic	6	6	6	6	24
History	.	...	...	2	2
Nature Study	...	...	..	3	3
Drawing	1	1	1	1	4
Music & Singing	1	1	1	1	4
Physical Culture	2	2	2	2	8
Labour Instruction	2	2	2	2	8
Socially useful work	...	...	2	2	4

EDUCATION IN THE ELEMENTARY GRADES

The aim of the 8-year courses is to produce pupils who are fully literate in th broadest sense of the word and for this purpose to emphasise greater precision i content and methods of instruction. Knowledge of the scientific laws that gover external reality, of the laws of the evolution of society must be an essential part o the pupil's mental equipment.

In classes V to VIII, the basic subjects are Russian language (or the languag of the national Republic in addition to Russian language), Russian (or nationa language) literature (which is introduced in class V), Mathematics, History of th U.S.S.R., Geography and Biology (introduced in class V), Technical Drawin introduced in class VII), one foreign language (introduced in class V), Drawing (i classes V to VII only), Music and singing, Physical Culture, Craft and Machine wor and socially useful labour. In addition pupils of classes V to VII give 180 hour in a year to 'socially useful practice'.

In the national Republics, three languages are taught during the V to VII year cycle, the native language and literature, Russian and a foreign langua (Table II).

TABLE II

The allocation of school time in a Russian language school in classes V–VIII

Class	V	VI	VII	VIII	Total per week
Total weekly hours	33	33	34	35	135
Subject :					
Russian Language		5	4	2	16
Russian literature	2	3	2	3	10
Mathematics	6	6	6	6	24
History and Constitution of U.S.S.R.	2	2	2	3	9
Geography	2	2	2	[illegible]	[illegible]
Biology	2	2	2	2	8
Physics		2	2	3	7
Chemistry			2	2	4
Technical Drawing			1	1	2
Foreign language	4	3	3	3	13
Drawing	1	1	1		3
Music and Singing	1	1	1	1	4
Physical Culture	2	2	2	2	8
Labour Instruction in School workshop	3	3	3	3	12
Socially useful work	2	2	2	2	8

An analysis of the allocation of the school time in the course covering classes I to VIII (compulsory education age-group) provides an indication of the distribution of emphasis in the curriculum. The total instructional time in all the eight classes (8611 hours) is distributed as follows :

General school subjects	6199 hours	72 per cent
Labour training and socially useful work	1315 hours	15.2 per cent
Physical culture, Music and Drawing	1097 hours	12.8 per cent

The time allocated for general school subjects (6199 hours) shows the following distribution :

Language group	48.5 per cent
Mathematics & scientific technical subjects	40.5 per cent
History-Geography	11.0 per cent

CURRICULUM IN THE SECONDARY GRADES

The aims of secondary education are defined in terms of the needs of the national economy. On the one hand the secondary school must educate young people comprehensively in the fundamentals of sciences and give them a firm grounding for the later task of research and preparation of specialists in institutions of higher learning. On the other hand it must 'train a worker who would rapidly master the habits and methods of work in the conditions of integrated mechanisation and automation." It is the conviction of Soviet educators that vocational training through practical work and 'persistence and systematic study' of fundamental theoretical subjects are not conflicting aims but that they are mutually reinforcing and cannot be achieved effectively in disjunction.

Since a substantial portion of the school time in the curriculum of the higher classes of secondary school is given to practical productive work, there is a greater measure of differentiation for the urban and the rural schools than at any other stage. The basic schools subjects in both types of schools are, however the same.

In class IX to XI the school subjects are Literature, Mathematics, History, Constitution of the U.S.S.R. (in class XI only), Chemistry, Biology and Technical Drawing (in class IX only), foreign language, and physical culture

In the urban secondary school, polytechnical training takes 36 school hours per week. In the rural secondary school, it takes the form of theoretical and practical work in agriculture.

An interesting innovation in the revised curriculum is an allotment of two periods per week for 'optional subject'. This is to enable the pupil to make a deeper study of any subject of his choice in the curriculum. It should not be surprising if in the years to come, and particularly when the duration of secondary education is extended to twelve years, more time is allotted for 'optional studies' since the device is a convenient means for giving to the talented pupil more time to develop their specialities. It also helps the backward pupil to make up in the difficult subjects.

TABLE III

Distribution of school time for Classes IX-XI in an urban secondary school.

(Russian language school)

				Total
Total weekly hours	38	38	38	114
Class	IX	X	XI	
Subjects :				
Literature	3	3	3	9
Mathematics	4	4	4	12
History	2	3	4	9
Constitution of the U.S.S.R.	...	...	2	2
Economic Geography	...	2	2	4
Physics	4	4	2	10
Astronomy	...	1	...	1
Chemistry	2	3	2	7
Biology	3	...	...	3
Technical Drawing	2	...	...	2
Foreign language	2	2	3	7
Physical culture	2	2	2	6
General Technical Subjects and Production Work	12	12	12	36
Optional subjects	2	2	2	6

The distribution of time for a rural secondary school has a different pattern (Table IV).

TABLE IV

Distribution of time for a rural secondary school

(Double figures in a class indicate [illegible])

				Total
Total weekly hours	38	38	38	114
Class	IX	X	XI	
Subjects:				
Literature	4	4	3	11
Mathematics	5	4-5	5	14.5
History	4	4	3	11
Constitution of U.S.S.R.			2	2
Economic Geography		3-4	2-3	6
Physics	4	4	4-5	12.5
Astronomy		1		1
Chemistry	2-3	3	3	8.5
Biology	4			4
Technical Drawing	2-3			2.5
Foreign Language	3	3	3	9
Physical Culture	2	2	3	7
Bases of Agricultural Production and Practical instruction	5	8	7	20
Optional Subjects	2	1	2	5

Productive work in the farms is fixed according to the season and averages 54 days (6 hours per day) in a year for classes IX and X each and 18 days for class XI.

The subject-wise allocation of time in a rural school appears to be larger than in an urban school. This, however, is not so, if the totals for the school year are compared. The pupils of a rural school undertake productive work on the farm during agricultural seasons, which cuts into school time to some extent. In a rural school the total yearly hours for school subjects is 2,669 as against 2,712 in an urban school. In covering the course of the last three secondary classes, a rural pupil gets slightly less school time than an urban pupil in literature, mathematics, Constitution of the U.S.S.R., Physics, Astronomy, Chemistry, Technical Drawing and Physical Culture; he gets more time in History, Economic Geography, Biology and Foreign language.

The total school year covers 4,068 hours for optional subjects (in rural school 184 hours). Of this 2,712 hours (66.6%) are allotted to school subjects and 1,356 hours (39.4%) to theoretical and practical instruction of polytechnical character. The time allotted for general school subjects (2,712 hours) shows the following distribution:

Literature and language group	22.1 per cent
History, Geography, Constitution	20.4 ,, ,,
Physical Culture	8.3 ,, ,,
Mathematics, Science and Technical	49.2 ,, ,,

SCIENCE IN THE SECONDARY GRADES

The recent spectacular achievements of Soviet science have served to focus attention on the system of science education in the U.S.S.R. Undoubtedly, the system of science education in the schools has laid the firm foundations on which the higher institutes and universities have been able to build a highly specialised structure of scientific knowledge and research, but it may also be pointed out that the objectives of teaching science in the schools are not conceived solely in terms of future preparation of specialists. They aim on the one band, at cultivating in the pupils a scientific view of the objective world as an essential aid to a materialistic interpretation of reality, and on the other, at promoting an understanding of principles which underlie the modern modes of production so that they may participate intelligently in the processes of production. As an instrument for forming a view of the external reality, science is equated in importance with 'social sciences', the principles of the former show the laws governing nature, and the laws of social sciences disclose how society evolves in inter-action with nature. The relation of science with the modern modes of production gives to the teaching of science an immediate practical relevance and to laboratory and applied work a weightier emphasis.

Of special importance to an appraisement of science education in the schools of the U.S.S.R. is the programme of out-of-school activities. Science education is the sum total of class instruction and the stimulation to scientific talent provided through the 'Circles', 'Stations', 'Pioneer's Palaces', etc.

In the eight-year school programme, 24 hours per week are given to scientific subjects out of a total of 238 school hours in a week, and in grades IX to XI 21 hours out of a total of 110. The programme of science education is, however, powerfully reinforced by the scientific orientation of polytechnical education.

In grades I to III, language lessons carry a substantial element relating to information about plant and animal life. This is systematised in a course on nature study which is introduced in grade IV. Formerly this was an elementary course in biology but the new curriculum has broadened and reorganised it into a course of nature study. The objectives of the course are, "to show connections between different elements of nature which are understandable to fourth grade pupils, to acquaint the children with man's use of nature in the process of labour, with the life around them, with the practice of communist construction on the basis of the extensive application of the principle of regional studies". The course covers observations of seasonal phenomena, study of the work of people in agriculture and factories, properties of water, air and certain minerals.

Biology

Biology is introduced in grade V and continued to the end of grade IX. Two school hours per week are given to it in grades V to VIII and three hours in grades IX (in rural areas, four hours.)

The course in biology consists of four sections arranged in sequence (botany ; zoology ; anatomy ; physiology and hygiene ; and the foundations of general biology).

The objectives of the course are defined as

"(a) to give pupils a systematic knowledge in basic biology and to reveal its significance in agriculture, in other branches of the national economy and in the health services ;

(b) to teach pupil the essential skills and habits of work in laboratories, in the nature corner, on the experimental school plots, and also in production, devoting special attention to experimental work of importance in the economic field ;

(c) to instil in the pupils a materialistic ideology, to lay bare the reactionary essence of religion, the harm caused by superstition and prejudices ;

(d) to develop in children and adolescents a love for nature, a desire to actively safeguard nature and to increase its wealth."

The course in botany is studied in grade V and the first three quarters of grade VI. Pupils are taught elementary knowlege of the structure, life, development and variety of plants and their significance to the national economy. The function of green leaves and the inter-relation between green plants and living animal organisms are explained. In grade V, nearly half the total time is given to practical work and demonstration including excursions.

In grade VI various types of cultivated and decorative plants are studied, potato, cabbage, wheat, apple tree, lichen fern, etc. An introduction is given to the biological basis for breeding agricultural plants which also provides the point for studying the life and work of E.V. Michurin. The course also covers conservation of the plant life of the U.S.S.R. and the general development of plants on earth. In autumn and spring, pupils carry on practical work in the school experimental plot and take part in community services such as planting trees in public squares.

Elementary zoology is introduced in the last quarter of grade VI and in grade VII. The course is designed to explain the structure and historical development of animals, how they conform to their environment and the modes of adapation and how the animal kingdom of today with its variety of forms came into being. Commencing with the study of unicellular animals, the course covers hydra, worms, insects (their influence on agriculture and health), fish (and how they are important for the economy of the country), reptiles, and closes with mammals. The topics are related to experimental and practical farming or to the national economy.

In grade VIII, the course covers 'The structure and Life of the Human Organism,' including elements of personal and social hygiene. Pupils are given an exposition of the structure of the human organism, cells, bones, muscles, tissues and reflexes They study the process of metabolism in the human organism, the nervous system and the function and hygiene of various organs The contribution of Russian scientists and particulary Pavlov is explained. The course closes with an elementrry exposition about the origin of man and relates it to what the pupils would have learnt earlier about the evolution of the plant and animal kingdoms. The practical work consists of dissection of animal organs and their identification.

The total course in biology in grades V to VIII provides the foundation for a knowledge of general biological concepts which are introduced in Grade IX. The course in grade IX is based on the principles of Darwinism with evolution as the main theme It covers organisms and evironment, their inter-relation and modes of adaptation, inheritance and variability, artificial selection, the origin of species and the contributions of certain scientists. (Darwin, Michurin and Timiryazev). The concluding theme is the origin and evolution of life on earth, with reference to plant and animal life and man.

Physics

The study of physics is introduced in grade VI and continued through grade XI. In the reorganised curriculum more time is alloted to the subject than before. Physics and chemistry are considered fundamental subjects in relation to polytechnical education, and a substantial part of polytechnical education is an extension of practical and applied work in physics and chemistry We formed the impression that more research work in the methodological aspects of teaching physics and chemistry is being done at any time in the various Pedagogical Institutes than on any other subject.

In grades VI to VIII, 7 school hours a week are allocated for physics and 10 in grades IX to XI. The objectives of teaching physics are stated as,

* 'enabling pupils to understand the basic principles of mechanics, sound, heat, electricity, magnetism, light and atomic structure,
*"helping them to see these principles at work in industrial processes, and preparing them for future practical activity and vocation and in serving the goals of communist society,

*"forming a scientific world view and lay bare religious prejudices and superstitions,

*"establishing the connection between theory and practice in teaching the physical laws and their application,

*"establishing inter-relationship between physical phenomena and magnitudes and their variations. Pupils learn units of measurement and the concept of length, area, mass, force, etc. Thirty hours are allocated to the properties of solid, fluid and gaseous bodies. Introduction to the structure of matter takes 4 hours and mechanical motion 10 hours, covering uniform motion, average speed and variable motion, the inertia of bodies and friction. Six hours are to be given to trips and excursions. The pupils complete experiments on measurement by scale, sliding calipers, etc., determination of the volume of a solid body, weight of bodies, force of pressure and pressure of hard bodies on support, use of plumb line, barometer, levers, pulleys, air and water pumps.

In grade VII, 37 hours are given to mechanical motion, 8 hours to sound phenomena, 47 hours to heat phenomena (expansion of bodies with heating, transfer of heat, transition of a body from one state of aggregation to another, heat engines) and 6 hours to trips and excursions. A pupil has to complete seven experiments covering measurement of temperature, use of calorimeter, operation of a steam engine and internal combustion engine, etc. He should be made familiar with examples of mechanical motion and force in industry, transport and agriculture, the role of fly wheels, conveyors, bearing materials, gear box, winch, excavator, etc., of heat phenomena in foundry, the use of alloys, steam boilers, locomotives and internal combution engines.

In grade VIII, 105 hours are allocated to physics. The course covers sound and light phenomena (15 hours), electrical phenomena (69 hours), which include current, resistance, voltage, electro-magnetic phenomena and radio. The pupils are introduced to the structure of atom. In conclusion, 10 hours are devoted to the recapitulation of the entire course in physics from grade VI to VIII. Two hours are set apart for a concluding talk which is devoted to explaining the value of physics in the development of the national economy through mechanisation and electrification, and six hours for trips and excursions. The practical experiments are designed to enable pupils to acquire the skill of reading electric instruments, the assembly of the galvanic battery, use of ammeter voltmeter, various types of rheostats, thermo-electric devices, the wiring of an electric bell, etc.

The course in physics for the last three grades of the secondary school (IX to XI) is formulated on the principle that the study of physical phenomena, concepts, laws and theories should be combined with a demonstration of their practical application and that the technical problems included in the programme should be so selected that they reveal the laws on which the mechanism operates.

The course for each grade at the secondary stage concludes with a study of specific machines

In grade IX 117 hours are given to physics. The course deals with mechanics and acoustics. The main units of study are, variable motion (16 hours), Newton's laws of motion (20 hours) curvilinear and rotary motion (16 hours) mechanical energy (10 hours), work of mechanisms and machines (6 hours), motion of fluids and gases (10 hours), oscillations and waves, (13 hours), sound (5 hours), practical experiments (10 hours). Six hours are given to excursions and four to recapitulation The pupil studies the working of machines for power transmission, the gearbox of the hoisting crane, and the carburettor.

In grade X, the course includes molecular-kinetic theory (3 hours), heat, work and internal energy (10 hours), properties of gases (10 hours), properties of fluids (6 hours), properties of the solid body (10 hours), vapours and their properties (10) ,heat engines and their application (10 hours).

The rest of the time is given to the study of electricity and the units are,

- electrical charges and electrical field (15 hours)
- electronic conductance of metals (12 hours)
- electronic phenomena in a vacuum (6 hours)
- ionic processes in gases (4 hours)
- ionic processes in electrolytes (4 hours)
- conductance of semi-conductors (4 hours)
- Magnetic field and electro-magnetic induction (10 hours)
- alternating current (13 hours)
- electro-magnetic oscillations and waves (11 hrs)
- production and utilisation of electric power (3 hrs)

Trips and excursions are given three hours and practical exercises 10 hours. The concluding theme of the course is to elucidate the practical problem of production, transmission, distribution and utilisation of electric power and the development of electrification in the U. S. S. R.

Only 68 hours are given to physics in grade XI. The units of study in the course are : Optics, which includes geometrics (15 hours), wave properties of light (9 hours) and quantum properties of light (6 hours) and the physics of the atom and nucleus. The latter includes, structure of the atom and nucleus (9 hours) energy level of electrons, isotopes and utilisation of atomic energy for peaceful purposes. Practical exercises take 10 hours, excursions 3 hours and recapitulation of the whole secondary course 13 hours

Chemistry

Since some grounding in mathematics, physics and biology is essential before a pupil can be introduced to a course in chemistry, the subject is started in grade VII. Two hours a week are allocated for chemistry in grade VII and VIII. The new syllabus aims at making the elementary course self-contained and to build on it a systematic course in grades IX to XI of the secondary school. Formerly the chemistry course was constructed as a single unit from grade VII to X. Some Soviet teachers seem to be of the view that the new syllabus for grades VII to VIII is somewhat overloaded.

The programme of the eight-year school provides an elementary course in inorganic chemistry and is intended to give to the pupils elementary information on the properties of *some* of the *most* important chemical elements and their compounds and teach them how to handle various substances and chemical equipment. In the teaching of the subject, its importance in the national economy and the achievements of Russian scientists are stressed.

Starting with substances and their transmutations the course covers structure of substances from molecules and atoms, basic laws of chemistry, oxygen, air, combustion, hydrogen, water, valence, oxidation, metals, acids, bases, and salts. The pupils are taught how to express the composition of substances and their chemical conversion and reaction by symbols, formulae and equations.

As in other subjects the teaching of chemistry is given a practical bias. Thus in the study of oxygen, its role in fuel combustion is explained. When studying acids, their household and industrial uses are discussed. In the theme relating to metals, the properties of the most important metals, corrosion of metals and anti-corrosion measures are explained. A theme on mineral fertilisers is introduced after the pupil has studied oxides, bases, and acids and salts. The programme contains a list of experiments to be conducted by pupils at the conclusion of each unit of study. Field trips and visits to chemical plants, construction, sites, drugstores, railway workshops, farms, etc., form an integral part of the chemistry programme.

The elementary course in chemistry in grades VII and VIII forms the basis for introducing in higher classes Mendeleyev's Periodic Law and Periodi System of Chemical Elements. The course for grades IX to XI covers inorgani and organic chemistry, the first two years being assigned to the former and th last year to the latter. The main theme of the course in inorganic chemistry i the study of the Periodic Law. To lead up to the main theme, the cours starts with the three natural groups of elements: the alkali metals, halogen and the oxygen group. Thereafter the periodic law and periodic system o Mendeleyev are taught. This is followed by a unit on the theory of the atomi structure in the light of which is studied the periodicity of elements and the nature of chemical transformations. 'Bases of Theory of Electrolytic Dissociation are studied as an independent theme which includes units on titration, oxidizing deoxidising reactions and the electrolysis processes. Then follow the themes on Nitrogen and Phosphorus', 'Carbon and Silicon' and 'Metals'.

The course in organic chemistry starts with hydro-carbons and an exposition of A. M. Butlerov's thoery about the chemical struture of organic compounds. Other themes of study include esters (for chemistry of fats), the alcohols and aldehydes (for carbohydrates), amino-acids (for proteins), organic acids, the amines, etc. For more detailed study are selected such substances as methane, ethylene and acetylene. Considerable attention in the course is given to the study of synthetic high-molecular substances and the materials which are created from them.

In covering the course and carrying out the laboratory experiments, pupils are expected to study the chemical procesees in plants and factories. For example when compounds of sulphur are studied, they must observe the production of sulphuric acid In studying ammonia, they are introduced to the technology of its industrial production.

Astronomy

Astronomy is studied for one year in grade X and takes one hour a week. The course covers diurnal rotation and annual revolution of the earth, the appearance of the sky, astronomical distances, the solar system, the structure of the universe and the origin and evolution of celestial bodies. The achievements of Russian scientists in the field of astronomy are explained.

SCHOOL MATHEMATICS INSTRUCTION
IN
EUROPE

(Based on a report by **HOWARD F. FEHR**)
Teachers' College Cloumbia University, U S A

Modern concepts are replacing the old classical approach to Mathematics teaching in the elementary and secondary schools throughout Europe. European schools are eliminating, what the International Conference of Mathematicians have agreed are unnecessary parts of classical mathematics and are adding some of the newer mathematics. The schools are revising traditional courses to coincide with contemporary thinking on the subject"

These findings were corroborated at the International Congress of Mathematicians at Stolkholm. Reports from more than 20 countries indicate that widespread reforms in secondary school mathematics are under way all over Europe.

Probability and statistics, part of the 'new mathematics' advocated by mathematics educators in the United States and abroad, have been introduced in the secondary schools in nearly all European countries. Many countries are using the report brought out by the Office of the Scientific and Technical Personnel. The International Seminar on improving Mathematics education held in 1959 in Royaumont, France, made many recommendations which form the basis for changing school instruction in Mathematics, in many Countries. The report's chief recommendation was for universal shift in emphasis in mathematics teaching, stressing the logic, structure and unity of mathematics as a whole, instead of the mere solution of routine problems in isolated branches of the subject.

Denmark, Finland, Norway and Sweden have formed a Scandinavian Committee for modernising school mathematics. The Committee studied the existing programme in each member country and has prepared books on

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Dr. Fehr is Head of the Department of Mathematical Education at the Teachers' College, Columbia University. He made two trips to Europe this year to study the status of school mathematics instruction at the request of the office of the Scientific and Technical Personnel and the Organisation of Economic Cooperation and Development, which has its headquarters at Paris. The purpose of his visit was to determine to what extent the recommendations of the report of the seminar "new thinking in school mathematics" were being carried out. This article has been adopted from the news office for release by the Teachers' College, Columbia University of Thursday, September 27, 1962.

modern Algebra Geometry, probability and calculus for the high school years 10 to 12 Similar programmes have been written for the years 7 to 9.

In Italy, five mathematicians, working with the Ministry of Education, high school teachers and consultants from the Organisation for Economic Cooperation and Development are preparing a new programme for the senior year of high school The programme in large measure, will treat geometry from a modern viewpoint. In Greece, the Ministry of Education has appointed a national Committee on mathematics instruction consisting of three of the country's top mathematicians, three teacher-trainer teachers in mathematics and three high school teachers

The group is rewriting the entire high school program, beginning this year with grade seven The textbook for grade seven, just completed, was written by teams of mathematicians, educators and teachers who used the O. E. C D. report as a basis for changes. Their work resembles, to a high degree, that produced by the School Mathematics Study Group in the United States.

Japan has prepared a new syllabus modernized to follow the reforms now going on in the United States, and is retraining its teachers this year and will inaugurate the program in 1963. Russia has given serious study to the O. E. C. D. report and will undoubtedly consider its recommendations as it reforms its own program.

Many of the report's suggestions are now an accomplished fact in some of the countries. The changes are the first in more than a half a century for a school *subject already badly behind the times.* A *specific proposal* in the O. E C D. report is that Euclid's treatment of geometry must be eliminated--and so must all other "dead, useless, outmoded or unimportant aspects of mathematics."

Euclid's approach to the study of geometry, taught to youth in many lands for countless generations, must either be greatly modified, as it has been by the School Mathematics Study Group in the United States, or replaced with an imaginative, daring and quite revolutionary program in genuine accord with modern university mathematics,

Euclid's ideas are useful but they must be studied in a manner required by modern scientific and technical work and as applied in natural science, in industry, and the behavioral sciences--that is, as arithmetical, as opposed to synthetic, space, which is the heart of mathematics.

Among agreements and conclusions reached at the eighteen-nation seminar in Paris and now being studied for possible adoption by many of the participants are the following :

There is urgent need to adapt school geometry and algebra to the "sweeping advances" in modern mathematics. This demands elimination of "much obsolete or technically valueless" material from the traditional curriculum in the treatment of plane and solid geometry, algebra and trigonometry. More thorough teaching of the "logical" aspects of these subjects—as opposed to rote or mechanical learning of them—is 'imperative."

Another immediate task is to teach geometry and algebra as related subjects and as part of unified mathematics they should be so taught that the difference between the two will gradually disappear. If general progress is to be achieved, Euclid, as now taught, should be greatly modified. The essentials of Euclid can be learned intuitively from ages 11 to 14, and, afterwards, a few months of study will suffice to make clear the system of axioms and other phases of the subject.

Euclid's synthetic geometry, as a study of space can be replaced by a program of elementary mathematics in which deductive geometry is treated by the use of vectors, or real numbers, and later merged with algebra. An algebraic treatment of the subject is proposed.

Trigonometry would enter the mathematics program naturally, not as a separate subject, but as a part of algebra and geometry, and later as part of analysis. Logarithms used to be the "speed method" of doing arithmetic computations. They have been replaced by the electric calculator and electronic computer. The solution of triangles would be greatly simplified, without the use of logarithms.

No matter what program in geometry is adopted, it is generally agreed that, during the ages 11 to 13, an intuitive-physical study of two and three space geometry should be the initial phase of learning.

Here children study by drawing, measuring, making models and investigating practically all the useful facts of geometry. From 13 to 15, the deductive phase of geometry should gradually enter instruction. After age 15, the axiomatic structure of vector spaces must be developed.

The gradual departure from physical reality to formal geometric abstraction and structure should be accomplished by the time the student enters the university.

The seminar proposed the introduction of elementary probability and statistical inference in the mathematics of secondary schools. Statistical inference has been called the subject in which one learns to make decisions on insufficient evidence.

A NEW PHYSICS PROGRAM FOR SECONDARY SCHOOLS

· UNITED STATES INFORAMTION SERVICE, NEW DELHI

The PSSC physics program is designed to show students some of the structure of physics and how it was discovered and understood by human beings The program concentrates on fewer facts than are usually included in an elementary physics course. Understanding these facts emphasized, memorization is not. Considerable time is spent on the stories running through physics which tie together the facts with explanations. Reasoning and careful observation are required to understand the stories. By working with simple apparatus designed with these purposes in mind, students can see how they use their developing ideas to steer their experiments. In this way concepts are developed, not just asserted. The laboratory is an important tool in learning ideas of science and of how science is built. The laboratory work in this course is on an equal level with the textbook, class discussions, and films as a means of learning and teaching. The tools of learning are :

(1) A new textbook.

(2) Laboratory experiments and simplified apparatus.

(3) A set of films which augments the laboratory, summarizes and integrates the various fields of study, and sets the tone and standards for the course.

(4) Achievement tests designed to stimulate the application of knowledge and techniques to new situations and problems.

(5) An extensive library of paper-bound books on special and related topics.

(6) A teachers' guide which provides background material, makes concrete suggestions for class and laboratory activities, and discusses critical sections of the course at the teacher's level.

A brief description of the manner in which the PSSC course presents the unifying principles of physics, and the manner in which these tools of learning are employed, is contained in the following excerpt from the preface of the textbook.

THE PSSC COURSE

The PSSC course consists of four closely inter-connected parts. Part 1 is a general introduction to the fundamental physical quantities of time, space and matter: how we grasp and how we measure them. [illegible] of the almost boundless range of dimensions from the enormously large to the infinitesimally small, from microseconds to billions of years. He finds out how [illegible] can be measured. He learns that instruments serve as an extension of the senses. Laboratory experience shows how we first measure by direct counting, and then extend our range of measurements by calibrating and using simple instruments such as stroboscopes or range finders.

From these experiments measuring time and space, the student comes to an understanding of velocity and acceleration, of vectors and of relative motion. He then goes on to study matter, which we see moving through space in the course of time. In this first examination of matter, we develop the concept of mass and of its conservation. We then use the evidence of physics and chemistry to show that matter is made of relatively few kinds of atoms. Direct experience is provided in the laboratory. There, for instance, the student estimates the size of a molecule from measurements of thin films of oil. Motion pictures extend and enrich direct laboratory experience by showing experiments which are beyond the reach of the students.

Throughout, the student is led to realize that physics is a single subject of study. In particular, time, space, and matter cannot be separated. Furthermore, he sees that physics is a developing subject, and that this development is the imaginative work of men and women like him.

The topics in the PSSC course are selected and ordered to progress from the simple and familiar to the more subtle ideas of modern atomic physics. In Part I we have looked at a broad picture of the universe. Now as we examine certain fields of physics in more detail, we start in Part II with light. We see by light, and the student moves easily into a study of sharp and diffuse shadows, reflection in mirrors, and the refraction of light at optical boundaries. The natural development of the subject leads up to develop a particle theory (or model) of light. Its discussion illustrates repeatedly the manner in which virtually all scientific knowledge develops. Again films—for instance, the film on the pressure of light—help the student to go beyond the laboratory.

Under continued scrutiny the particle model proves inadequate, and the student finds that we need another model—a wave model. The laboratory again provides an unexcelled source of experience, and here the student becomes familiar with the properties of waves. He observes the behaviour of waves on ropes and on the surface of water. He begins to recognize the group of characteristics that constitute wave behaviour. Knowledge of interference and diffraction comes directly from a study of waves in a ripple tank. For the first time, perhaps, the smears of light around street lamps, the colours of oil slicks, and the formation of images by lenses appear as aspects of the wave nature of light.

During the first half of the course, the principal emphasis is on the kinematics of our world - where things are, how big they are, and how they move, not why. In Part III we turn to a closer look at motion, this time from a dynamical point of view. With simple laboratory apparatus the students discover Newton's law of motion. They learn to predict motions when forces are known and to determine forces when motions are known. Thus armed they follow the extraordinary story of the discovery of universal gravitation, Newton's educated guess with which he jumped from the known laws of motion to the law of gravitational attraction.

The laws of conservation of momentum and of energy are introduced through a combination of theory and laboratory exploration. These laws form a substantial portion of Part III, and we stress their use in situations where detailed observation of the motion is not possible, as in Chadwick's discovery of the neutron and in the kinetic theory of gases.

Part IV introduces the student to electricity and through it to the physics of the atom. Here the student uses the knowledge of dynamics gained in Part III. We begin with qualitative observations, then proceed to a quantitative study of the forces between charges. We learn how to measure very small electric forces and discover that electric charge comes in natural units. We then study the motion of charged particles in electric fields and learn how to determine the masses of electrons and protons.

Next comes a discussion of magnetic fields produced by magnets and currents, and a discussion of the forces they exert on moving charges. As a final part of electricity we discuss the induction laws and give the student a qualitative feeling for the electro-magnetic nature of light. Many of the fundamental ideas are explored in the laboratory--Coulomb's Law, the magnetic field around a current, the force exerted by a magnetic field on a current-carrying wire are examples.

Now we use the knowledge gained on a large scale to probe the structure of atoms. Following the work of Rutherford, we establish the nuclear model of the atom. But some questions are unanswered. Why, for example, is such an atom stable? Why doesn't it collapse by emitting light? In searching for answers, we discover that light is both grainy and wavy. Furthermore, we find that although matter behaves like particles, in some respects it also behaves like waves. By combining both properties, we can understand the stability of the hydrogen atom and the structure of its energy levels. In this part of the course, because direct experimentation becomes harder and more expensive, films bring to the student such experiments as the Millikan experiment and the interference of photons. At the end of the course we have arrived at the modern model of atoms.

Laboratory Apparatus and Films.

It was initially the intention of the PSSC to develop laboratory apparatus which might be constructed from materials which were generally available, such as rubber bands, toy motors, household bolts and conventional hardware. It was expected that the apparatus might then be constructed by the student at home or in his school shop, at trivial cost. Upon trial, however, it was discovered that the savings in money did not compensate for the additional burden this work placed upon the teacher, who was required to gather the necessary parts from stores and from local suppliers, and to supervise the construction. Apparatus is now manufactured commercially and supplied in kit form, the primary task of the PSSC was to provide designs which made it possible to set the price at a minimum.

The films offered by PSSC bear little resemblance to those previously used in secondary schools, which have been for the most part self-contained "enrichment" films or (more recently) which are intended to present the entire subject matter of a course. The PSSC films, in contrast, are part of a complex which includes the text and the laboratory. Each film presumes to some degree a knowledge of what has been presented earlier in the course, and is intended in part to open those avenues which the student will later traverse. Most films include an experiment which, for any one of several obvious reasons, cannot be done in the school laboratory or demonstrated in the classroom. In others an attempt is made to present an experiment carried out with relatively simple materials, and within the capacity of an earnest student to duplicate. Some films summarize and integrate a topic by presenting several experiments or phenomena which could not be assembled by the teacher. Finally, certain difficult portions of the course are presented on film in the belief that the student will be best served if all the learning tools— the text, the laboratory, the classroom discussion and the film— converge on the problem.

Most of the films are of use in any physics course, but their best and most efficient use is within the context of the PSSC course.

Trial and Use.

There were between 1800 and 2000 teachers using the PSSC program during the 1961-62 school year with around 75-80,000 students. This is approximately 20 per cent of the secondary school students in the U.S.A. enrolled in physics and represents a significant increase over last year. The growth of the PSSC program is as follows : In 1957-58, there were 8 teachers and 300 students; in 1958-59, 270 teachers and 11,000 students; in 1959-60, 560 teachers and 22,500 students, in 1960-61, 1,100 teachers and 44,000 students. In addition, there are over 1000 teachers using various parts of the course materials, i.e., lab, films, etc., with a conventional physics textbook.

Considerably less than five per cent of the PSSC teachers drop out of the program, because they feel the course is not suitable. Of the 125 dropouts from the 1100 teachers in 1960-61, 41 alternate physics and chemisty, 21 did not teach in 1961-62; 20 changed positions and could not put in the course, or are teaching courses other than physics, 8 taught the course in part; 35 gave no reason, or indicated the course was not suitable for their students

The NSF sponsored summer and in-service institute has been an essential part of the overall PSSC program and has helped make the course immediately useful to teachers and students. Teachers become familiar with the new materials and their inter-related use by attending a summer institute program for six to eight weeks or an in-service institute program for a year at universities and colleges throughout the country. The PSSC institute programs are led by at least one physicist and one or more high school teachers experienced in teaching the PSSC program. Evaluation of the teacher training programs has established their effectiveness, not only in acquainting the teachers with the substance and philosophy of the course, but in strengthening their backgrounds in physics. Since the course is more extensive and penetrating than the conventional course in physics, it is strongly recommended by the Committee that teachers attend a PSSC institute program before or during the first year of teaching the course. During the current academic year, there are 20 in-service institutes training teachers to use the PSSC program.

The reports from various feedback sources indicate that the PSSC program is going very well. The present edition of the text, lab guide, and teachers' guide, the improved apparatus kits, and a larger number of films available have contributed a good deal in bringing this about. Improved teacher training programe have played an important role too.

Most of the teachers even in their third and fourth year teaching the PSSC program find that there is more than enough material to cover in one year. The more experienced teachers have a better understanding of what material to emphasize and what material can be covered rather quickly and still not lose the continuity of the course. The time allowed for teaching physics is being extended in some schools to seven periods per week in place of five; and a year and a half (in a few schools, two years) in place one year. In addition, some teachers have become more efficient by making better use of the PSSC films*and by moving some of the PSSC material to general science and chemistry classes.

Generally, the more experienced the teacher becomes in teaching the PSSC program, the more acceptable the course becomes in the teacher's judgment for students of all intellectual levels From the beginning, there has been material with sufficient depth to challenge the brightest students. Successive revisions have not lost this characteristic. There is more evidence in the feedback recently to show that when ideas are developed first through the laboratory (followed by appropriate discussions, reading the textbook, and working on problems based on these ideas at the appropriate time) students with average ability and interests in English and the humanities are able to profit considerably from the PSSC program. Several teachers are using PSSC material with groups of "low ability" students and are encouraged by their results, especially when lab work is used extensively.

A question that is frequently asked is "How much mathematics is required?" One year of algebra and one year of geometry is sufficient, but students with additional courses in math will find them useful. Graphical analysis is introduced early in the course and used throughout.

Comments on the performance of students from PSSC classes in college physics are more reliable at the present time. A PSSC student is likely to have a better understanding of the fundamentals of physics though this is not always the case. In some classes, students have scored some 10 per cent higher on their hour exams, in others they have been advanced to sophomore physics standing. They are noticeably more enthusiastic and confident in the laboratory and usually feel that the course was valuable. For example, one teacher reported the following from a former student, which might be considered typical: "We were too young and immature to know at the time, but boy, how we now appreciate it."

Evaluation of performance in college physics courses by former PSSC students should be only one way to evaluate the PSSC program. Certainly much can be said for the effect that it is having on the larger group of students who take the PSSC course but do not go on to college physics. This will be a more difficult group to follow, but no less important.

Foreign Interest.

During the past two years, many people in countries outside the United States have expressed a desire to know more about the PSSC course. Many of these initial requests for information have evolved into active programs.

More than thrity-five teachers from abroad have attended PSSC summer institute programs in the United States. In addition, several foreign countries have organized working sessions for local teachers and have requested staff members from PSSC. In these sessions, the course materials and the ideas behind them were presented by PSSC staff members and the local physics teachers then considered how they would like to adapt the course for their own use. In some cases they have decided to run several pilot classes using the course as it is to see what problems will be encountered. They then plan to make changes where necessary, and prepare the course for widespread use in the local language if the results on the pilot classes are satisfactory.

During the summer of 1961, PSSC staff members attended such working sessions in Israel New Zealand and an OECD-sponsored institute in England which involved teacher participants from all of the OECD countries. Also, PSSC staff members have gone to South America, Nigeria, Japan, Australia, and Sweden to discuss the course with interested teachers and physicists.

Translations of the PSSC textbook into Spanish, Italian, Swedish, and French are now in process, negotiations are underway for translations into Hebrew, Japanese, and Portuguese.

THE PHYSICAL SCIENCE STUDY COMMITTEE

The Physical Science Study Committee consisting of university and secondary school physics teachers, undertook in 1956 the task of developing an improved physics course for secondary schools The principal financial support has come from the National Science Foundation Additional funds were made available by the Ford Foundation, Fund for the Advancement of Education, and the Alfred P Sloan Foundation. The Committee's work is currently administered by Educational Services Incorporated, a non-profit corporation.

The work of the Committee stimulated a general movement in the United States to improve education at all levels, elementary, secondary, and college. Similar groups are now at work in the areas of biology, chemistry, and mathematics.

Further Information.

All of the materials prepared by the Committee are now available from commercial sources. Teachers planning to put in the PSSC program are urged to attend a PSSC institute before using the materials.

The Physical Science Study Committee is interested in rendering whatever services are useful to those individuals who wish to put in the program, know more about it and how it came into being, etc. Such information may be obtained from:

Physical Science Study Committee
Educational Services Incorporated
164 Main Street
Watertown 72, Massachusetts

Copies of the textbook and laboratory guide and teachers' guide may be obtained from:

D. C. Heath and Company
285 Columbus Avenue
Boston 16, Massachusetts

A laboratory apparatus catalogue may be obtained from:

Macalaster Scientific Corporation
253 Norfolk Street
Cambridge 39, Massachusetts

The Macalaster Scientific Corporation successfully completed on March 1, 1962 a two year contract with ESI to manufacture the PSSC apparatus to approved ESI specifications. We feel that they will continue to supply quality low cost apparatus suitable for use in the PSSC program.

A film catalogue and information on previewing the films may be obtained from :

Modern Talking Picture Service, Inc
3 East 54th Street
New York 22, New York

The PSSC student achievement tests may be purchased from

Cooperative Test Division
Educational Testing Service
Princeton, New Jersey

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'DO-IT-YOURSELF' TEACHING TECHNIQUE FOR BASIC PHYSICS*

There was a run on soda straws in the Woodrow Wilson High School (Washington D. C.) cafeteria here recently. But not because the students were extra thirsty. They had just learned how to make a set of scales sensitive enough to weigh the wing of a fly using only two soda straws, a needle, a brass screw and matchbook cover. This 'do-it-yourself' physics apparatus was explained to them by Elbert P Little, executive director of the Physical Science Study Committee which is centered at Massachusetts Institute of Technology near Boston. Little's committee has developed a new physics course now being tested in eight high schools in the United States. Out of the window are the ancient problems of levers and pulleys. The student sumps right into the fundamental area of wave theory, which involves the crucial questions of modern physics. In Washington to attend an MIT regional conference, Little toted a 60-pound wooden case containing the science apparatus developed in conjunction with the physics curriculum to Woodrow Wilson for an impromptu demonstration. Almost all the equipment can be built by the student in his own basement at a cost of a few pennies or a few dollars.

"I could make those scales in 10 minutes," siad John Harlles Jr "I think I'll get a couple of straws from the cafeteria now."

"I often scrounge things that way," said Little, who with drapery rings, cake pans, anap beads, mirrors, clothes pins and orange juice containers was able to open up a new world of science for the students.

The equipment most pertinent to the course is a ripple tank, which projects wave motions on to the ceiling. With this tank, it is possible to measure wave lengths and frequencies, to demonstrate reflection, refraction and interference patterns, to be explain the principles of lenses, telescope and spectrescopes.

Usually such tanks are priced at $ 100 or more. But Little's model costs $ 6 or $ 7. The tank is made of an ordinary window frame into which a pane of window glass is set. On the floor under the window pane a 100-watt light bulb is placed. Driving mechanisms, to make either plane or spherical waves are made of wood, clothes pins and beads powered by six-volt motors from toys that can be bought for $ 1 or less.

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*By Courtesy of United States Information Service, New Delhi

Similarly, students examined a high-voltage generator, made out of a cake pan, orange juice mixer and world globe, which is capable of producing 50,000-volt sparks.

and looked through telescopes made of linoleum and lenses positioned by wooden curtain rings.

"It's amazing what a little imagination will do," said Bill Steele, a Woodrow Wilson senior.

Instruction in using the new equipment and textbooks will be given to 250 teachers at institutes this summer. By the following summer they are expected to give instruction to 2500 additional teachers. In that way, the course can be introduced easily into the public schools. Initial response is the eight pilot schools is enthusiastic.

Little's committee, supported $ 1,695,000 in foundation funds, also is developing 60 first-rate films for classroom demonstration and a series of paper-back books on special science subjects. The project was begun in 1956 by Jerrold R. Zacharias, MIT physics professor and Chairman of the Physical Science Study Committees.

MINIATURE WAVES FOR MINIATURE BREAKWATERS*

PIERRE DEVAUX

Reduced scale tests are today common for airplanes and ships. It is more unique to see this system of miniaturization applied to the preservation of ports, the stability of beaches and the tremendous impact of the sea.

When ports die......

However, this is exactly what the engineers in the Hydraulic Laboratory at Maisons-Alfort, created in 1939, work on. Scientific research on the movement of waters is exclusively studied in this laboratory where the effect — sometimes catastrophic — of these movements on fixed installations (ports, dams, canals and breakwaters) is noted

To represent the utility of such a laboratory, it is sufficient to consider the problems which are currently posed to the engineers. These problems are enormous from both a material and financial point of view. For example, one project concerns the problem of determining in how many years a large port menaced by silting will no longer be able to offer heavy ships the necessary water draught.

The technicians of Maisons-Alfort were also asked: *Is it profitable to spend 100 milliard francs for the expansion of a port which is constantly battered by breaking of the waves?*

The builders of dams have found themselves faced with problems in which the factors of stability are numerous as the cruel memory of the drama at Malpasset indicated.

How does one make artificial waves ?

Let us pass over the groups of technicians leaning over their electronic calculators. The spectacle of large testing halls is not surprising; groups of serious men in white blouses building sand or plaster pies! Like children on a beach, these technicians build miniature channels in which more or less destructive bodies of water circulate

Several ports (Cherbourg, Royan and overseas Majunga) are reproduced on a

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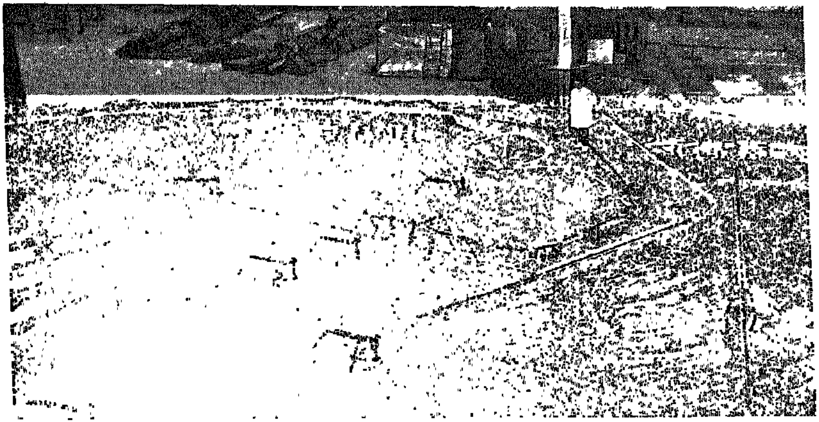
[*By Courtesy of the Embassy of France.]



scale of a hundred: and the reproduction is so faithful that all coastal details can be recognized. The swell of a thin stream of water, representing the English Channel or the Mozambique canal, breaks continuously against these miniature reproductions.

How does one create artificial waves? With the aid of enormous buoys or panels, oscillated by connecting rods which are in turn powered by engines with a constant speed. The tumultuous agitation of the water is filtered through special screens so that only regular waves are obtained corresponding to the exact concours of the natural swell.

The visitor is greatly surprised. It is difficult to believe that streams of water only several centimeters deep, which seem barely to surround constructions of hard sand, can act exactly as the millions of tons of ocean water rushing against the real structures.

The comparison, or rather the extrapolation, remains valuable, nevertheless, thanks to mathematical formulae of extreme exactitude and to curious material precautions.

For example, it is certain that capillary phenomena play a large role in the use of models although this phenomena is absolutely insignificant in the real movement of the sea. It is, consequently, necessary to reinforce certain river or canal depths of the reduced model with iron wire gratings which do not exist, of course, in reality.

The proportions are not even the same in height and in width, and the relationship of surfaces, and eventually those of weights, are different. However, the classical formulae of similitude, well known in mathematics, have been responsible for solving these multiple problems.

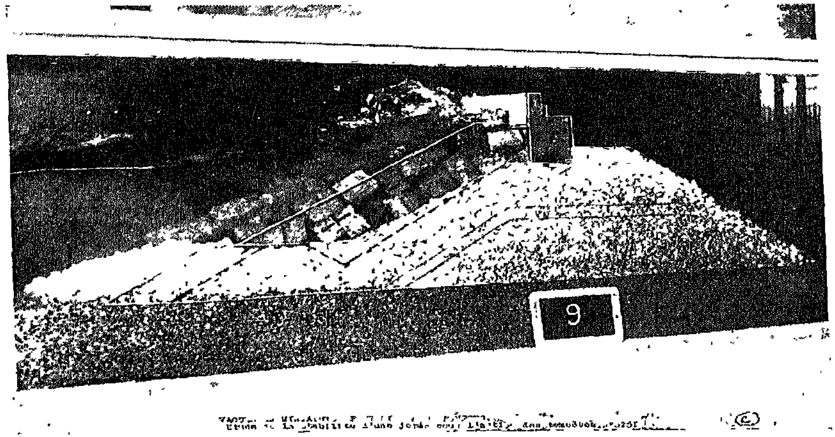
The same is true for time. And with this problem, the phenomena noticed are quick. In reality, natural effects which correspond to these phenomena are much slower. In the hydrodynamics laboratory, a week is enough to reproduce and study phenomena which would ordinarily be produced over several years. Similitude must, therefore, also be established for the scale of time.

Recently, a mobile device which allows a camera to film the evolution of a wave from its birth to its breaking point was installed in the laboratory. The point at which the wave breaks represents a critical instant during which the molecules of water, acquiring considerable speed, are capable of destroying important masonry and concrete structures.

Almost universal solutions

The following are several solutions worked out by the engineers who are conscious of the vast natural problems involved.

To the problem "In what year will the port of Majunga be invaded by sand?", the laboratory replied with exactitude "In the year 2020"!



This seems slightly funny, but for that time span of 60 years, the laboratory also indicated the points where dredging would have to be made as well as the volume of sand which would have to be dredged if the port were not really to be silted up by the year 2020 !

Another problem: "Is it exact that some ports are gradually being filled with alluvial deposits to such a point that these ports will soon be replaced by a forest of pine trees?"

The laboratory replied that a real menace existed for certains deltas. The imminence of this danger was carefully studied and the protections necessary against this possibility were carefully determined.

The agitation of the water in some ports becomes so great that at certain moments ships are menaced and must seek refuge in the open seas. For this problem, the engineers determined the degree of minimum protection needed in ports and indicated the structures which would guaranttee this minimum security.

Other questions which seem to come from literature or poetry have also been asked: "What is the influence of the presence of a school of fish on the flow of canal regulators in dams? Of aquatic plants in weir plants? Of the stream of rain on roofs? Of the formation of ice in rivers and canals? . . . .

Tests on models aided by the formulae of similitude allow answers to the problem . . . . and thank heavens that science can study with such exactitude the behaviour of the ocean for the profit and use of governments and people.

SCIENCE NEWS FROM JAPAN

HOT SPRING HAS BENEFICIAL EFFECT ON POLIO AND LEUKEMIA

In a remote area of Japan, a three and-half hour busride from the nearest railway station, there is a hot spring which reportedly has special curative power on polio, leukemia, rheumatis, neuralgia and both high and low blood pressure

Professor Sennosuke Tarusawa of the Iwate Medical College has recently disclosed his findings on the Tamagawa Hot Spring in Akita Prefecture in northern Japan. This particular hot spring is the only Japanese hot spring which contains hydrochloric acid, sulphuric acid and sulphur which have remarkable curative effects on these sickness and diseases, according to Professor Tarusawa.

His findings reveal that the hydrochloric acid contained in the hot spring causes peculiar eruptions on the skin of bathers, but such skin eruptions apparently work as automatic antigens against the viruses or toxins of various diseases and also invigorates the activities of cells and internal organs throughout the body. He reports that rheumatism can be cured up to 80 per cent after 28 days of bathing three times a day and infantitle paralysis up to 50 per cent after 90 days of similar bathing in the hot spring of 42° C

'ELECTRIC POWER GENERATED BY SEA-WAVE LIGHTS A NAVIGATIONAL AID BUOY'

A wave-power generator that produces enough electricity to light a navigational-aid buoy has recently been developed by an army officer attached to the Technology Research Head-quarters of the Japanese Defence Agency.

The Source of energy for the generating device, about three feet in diameter, is the undulation of waves. A pendulum, some cogwheels and a generator are inside the device, which is topped by a lamp.

This buoy-like device is floated on the ocean and secured by an anchor. An oil drum filled with sea water hangs from one side of the device and a lead weight from the other. The two weigh the same in the water but their mass difference makes one move slower than the other when buffected by waves Thus the cogwheels attached to the pendulum activate the generator to produce electricity, which lights the lamp.

There is also a device to regulate power output and keep the flow of electricity at a constant level. A storage battery inside the wave-power generator automatically stores extra electricity, which is necessary since the generator will be idle when the sea is calm.

Similar experiments to develop wave power generators have been carried out overseas, but none has reportedly been developed to the point where it is ready for production on an industrial basis.

[Information Bulletin, Embassy of Japan, No. 19 [illegible] 9 (15, 16) September, 1962.]

Introducing new books

TRENDS IN SCIENTIFIC TERMINOLOGY

Ed. By O. P. Sharma

National Bureau of Educational Publications,
New Delhi. pp 16+85+68 Rs. 7.50 1962

The question of the medium of instruction in schools and colleges has been exercising the minds of politicians, educationists and others for quite a long time now. While there is agreement as to the need of adoptiong the regional language as the medium in the high schools, there is divided opinion as to its suitability at the collegiate and post-graduate levels. The main objection comes when we consider the teaching of science subjects for which there are not enough standard textbooks in the regional languages. To produce standard text books in the various languages in India there should be some kind of uniformity in scientific technical terminology.

Trends in Scientific Termionology is a compilation of several articles on the problems of scientific terminology by eminent scientists and linguists. The book has a foreword by Dr. K. L. Shrimali, Union Minister of Education who stresses the fact that Science is universal and has no regional or national boundaries, and that technical terminologies should be based on international usage and as far as possible should be common to all Indian languages.

The book is divided into two parts : I) Scientific Terminology and Indian Languages and II) Scientific Terminology and World Trend. The first part contains articles by Indian scientists and linguists and the second part is a compilation of the development and trends of Scientific Terminology in some of the foreign countries.

In the first article, Dr. D. S. Kothari explains what is meant by International Terminology. He recognises two classes of technical words (1) words which are taken from ordinary speech and given a precise meaning and (2) words which do not occur in ordinary speech but are specially imported or invented for scientific purposes. The terms which constitute International Terminology belong generally to the second category. The primary aim of scientific terminology in Indian languages, according to Dr. Kothari, should lead to improvement in science education and accelerate the progress of science in the country. At the under-graduate stage he advocates the use of double terminology, one in the regional language and the other in English. This would enrich the Indian languages indirectly. He is also in favour of a common script for the country as an imperative necessity. This is doubtless a good proposition but it will be hard to convince the language pandits who are as great lovers of the language as they are of its script.

The procedure evolved for the coining of scientific terms by the Government of India is discussed in the article on while the role of scientific terminology in foregoing cultural integration is stressed in the article entitled. The need for an awareness of the problems of scientific terminology amongst writers, translators, scientists, students and laymen is made out in "The medium of Science Education."

Part II of the book attempts to draw analogies of our problems with those of other countries which have faced similar difficulties and have solved them fairly satisfactorily. Of special interest is the achievement in the U. S. S. R. which has more than a dozen fully developed languages. The same trend of enriching the language of the country with scientific terms is evident in the Japanese language. Countries like Israel, Indonesia and Turkey have also tended to use their own language along with the basic forms of International Terminology for Scientific communication. Expert assistance given by the Unesco to local efforts to improve terminology is described in another chapter. There is a useful bibliography of terminological glossaries at the end of this section.

The information contained in this book and the thoughts and views of eminent persons expressed here will be useful to our writers, translators and scientists who are encased in writing in one of the Indian languages.

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THE STORY OF A STONE*

D. N. WADIA

"God worketh slowly and a thousand years
He takes to lift his hands off. Layer on Layer
He made the earth, fashioned it and hardened it
Into the great bright useful thing it is.
Its seas life-crowded and soul-hallowed lands
He girdled with the girdle of the sun."

Once I had a conference with a pebble, one of those very familiar objects, which one sees everywhere around Jhelum and thinks no more of, and which the very donkeys that carry them on their backs hold in contempt. Certain pursuits in which I have been engaged for some years past have created in him a sympathy with my inquiry, and, in response, he enlightened me on the story of his past. He thus expressed himself:—

"*My history is long, and the tale that I have to tell of a long life of* restless adventures is almost illimitable. My antiquity is to be measured by periods too vast for your human comprehension, before which the most ancient records of man's history are but as events not even of yesterday but of the last hour. The Himalaya mountains and the seas that wash the Indian shores on the east and west, symbols of time and eternity to man, are, in comparison with the aeons of time that I have passed during my existence on this earth, mere evanescent phases that have come and gone without number. Within my experience, I have witnessed the birth and passing away of many seas, continents and mountains, and these, your important land-marks of the world of to-day, are the latest comers in a long line of such.

"When I was born, the world was in its infancy, and an altogether different world it was. I cannot exactly recall in detail the geography of the country of my birth. This much, however, is quite certain, that much of the north of India and Punjab of today lay deep under the waters of an ocean, the northern shores of which lay far beyond the plateau of Central Asia. Its southern shores defined a continent in the south, of which the Deccan is a small existing fragment. That graceful pendant, the island of Ceylon, of course did not exist then ; it, together with the Deccan, formed part of a continent that stretched far on the other side of the Equator, how far I cannot say: it may be, towards Madagascar on the west and Australia on the east. The one notable feature of this tract of land of which I have a distinct remembrance, (because, as you will learn presently, it was connected with my parentage), was that a high range of mountains ran across it from the site of the present Sahyadris (Western Ghats) to the north as far as the Pamirs. The Aravallis of today are a weathered and shrunk remnant of that lofty pile. The chisel of time has cut deep into them and out of their dust and debris built many a rock-system of India. I hold within me much of its substance and so do many of my congeners in the long line of descent.

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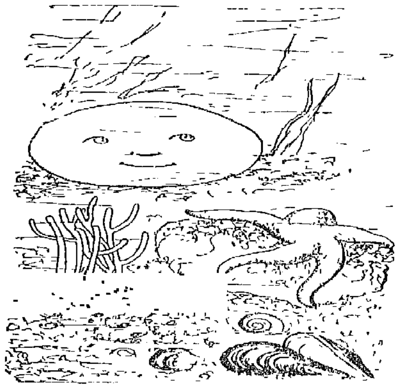
* Reprinted from the Prince of Wales College Magazine, Jammu and Kashmir, December, 1912.

"Such was the aspect of the physical world of my day. The world of living beings was stranger still, and far different from anything I have since beheld. It will want an effort of your imagination to realise the picture of that singularly desolate and barren world, from which all the varied and multitudinous races of animals which inhabit it today were absent. There were no quadrupeds, and no beasts of prey ; no birds broke the silence of the air, nor any of the orders of the reptiles broke the gloom of the woods, no frogs, no fishes, even many of the humble invertebrates were absent from the silent deeps of the ocean. They were yet to be born ; their advent was but faintly heralded by the few insignificant, but universally spread, lowly class of coral-like animals and some crustacea and shell-fishes, which lived in the sea. The land was even more thinly peopled. The hill-slopes and plains were clothed with a sort of vegetation that has its modern representatives in the lower sea-weeds, mosses and ferns. True, some of these ferns and weeds did shoot their arrogant heads high in the air in the manner of trees of today, but it was a barren splendour only, for, they were devoid of flower, fruit or seed such as you know them. Living upon their scanty products were a few animals mostly of the insect and worm class.

"Now as to my birth, I have said that on the borders of the southern continent, i.e. the tract of country now occupied by the Himalayas lay the Sea. The bed of that sea was my birth-place. The drainage of the land, gathered by a large river that flowed across it, was discharged, at its mouth, into the sea. Mingled in this water were loads of mud, sand and silt, as is the case with all running water on land. Some geologists, curious in these matters have calculated the rate of waste of solid land by the agency of rivers and rain. They have found that one such river, the Ganges, for instance, conveys 973,000 tons of such sediment daily to the Bay of Bengal. When you consider that not only the Ganges but other great Indian rivers, the Brahmaputra, the Indus, the Godavari, the Narbudda, the Krishna,—some of which carry even more silt than the Ganges—all assist in transporting the solid materials of the continent, you will realise that the waste of the hills and the plains is enormous, and will admit that, as the combined results of the action of all the rivers of the globe, the level of the earth is being reduced one foot in about every 6,000 years As is the case now, so it was in the past. For in all inquiries of this kind you can take this as a cardinal principle (from us who have been the witness of nature's work since the earth's infancy) · **The Present is the Key to the Past.**

"There, deep under the mantle of the ocean, I lay, a sheet of white sand. The successive floods of the river brought fresh loads of sand and these were laid down over those of the last season in a thin layer. Layer after such layer grew, as one tributary after another poured its freight of sediment. It was while I was lying in this condition of loose, unconsolidated sand, on the sea bottom, that I first made my acquaintance with living beings of the period. They flitted about in the waters, or fixed themselves in the growing sands, or crawled over them. Some of them were shell-fishes and star-fishes, some crustaceans and sea-lilies, others corals and sponges, then uncouth and primitive forms, in contrast with the same animals of today, I yet dimly remember. Their dead bodies, dropped upon the last layer of sand, would lie there till covered by the next deposit of sand brought by the next seasonal flood. Then a curious process would intervene between the organic and the inorganic, and by a slow chemical molecular change, the organic body would be replaced particle by particle, by the inorganic substance of the sand, but still preserving the details of its anatomical structure. Eventually that relic of the dead animal would be converted into stone, to remain there for ever in its stony sepulchre, to bear witness to many an important fact and circumstance in long subsequent ages. Many such organic fragments, shells and skeletons were entombed in this manner in the bed of sand which was the parent mass from which I was derived. Some of us still bear such *petrified* remains, which you call *fossils*,—chroniclers of

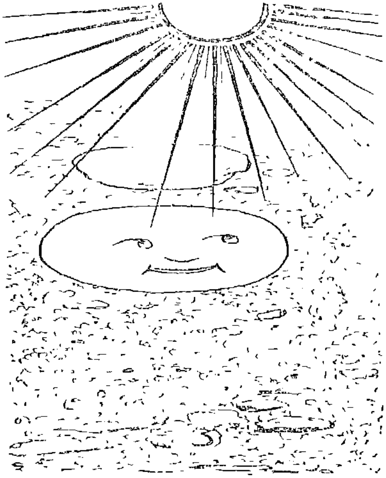


the life and conditions of their times. Well, the layers, or strata as you call them, continued to form one over another, each younger one resting on the next older, till in the course of long ages a thickness of some thousands of feet resulted. Under the pressure of the overlying mass, the lower (and older) beds were compacted and consolidated into a hard mass. Infiltrating water carrying limy or siliceous solutions introduced these substances into the sand beds; and they, acting as a kind of cement or matrix, converted the once loose sediments into a hard compact rock which you now recognise by the name of sandstone. Thus you see how I was formed out of the silt derived from the wasting of the land, no small part of which was contributed by the hill-slopes and valley-sides of the Aravallis. Up to now my days were happy. Protected under the cover of waters, gathered with my parent mass, I was a stranger to the never ending changes and turmoil of the inorganic world. My life of restless and infinite toil was yet to begin.

"Up to now the compacted and 'stratified' beds of sandstone were lying in their original horizontal position over the sea-bed. Then, by some far-reaching titanic process a slow upheaving of the earth began. The strata were compressed from the sides, twisted and folded — solid rock masses as we were — out of their original horizontal and level positions into curious unstable structures of arches and troughs. As a consequence of the upheaving movement, we began to emerge out of the depths of the ocean waters; old Neptune slowly retired from his old domain, and we were left high and dry. In a word the sea-bed was laid bare and converted into land, the new fabric being a piece added to the old southern continent.

"Phenomena so wonderful as the uprise of the sea bottom to form new land is difficult to conceive, and you are naturally astounded at the magnitude of the operations involved. But look around you and see whether the present geography of the world does not present some identical or parallel phenomena. Here again apply the same principle of inquiry, observe the workings of Nature today, and you will find a clue to its operations in the past. Has not the coast of Sweden for many hundreds of miles lately risen out of the Gulf of Bothnia? The coast of Siberia, east of the Lena, for over 600 miles has risen out of the sea and is still rising. The eastern and southern borders of Japan are undergoing a slow elevation, witness the marks on its beaches, ask its fishermen and sea-captains. The same disturbance of the relative level of sea and land is felt along extensive tracts of Labrador, Newfoundland and Greenland. But why quest so far? Have not similar things happened within historic times in India? Large areas, once famous historic sites, have been submerged under sea-water and converted into an inland sea, and other areas elevated beyond the reach of the waters to form mounds

"The coast of Kathiawar, the east coast of the Island of Bombay and the Konkan coast bear marks of recent alternations of the relative level of land and sea, and later still, though on a larger scale, are the changes in Assam and Chittagong But you must not imagine that these great geographical revolutions were accomplished in a few years or even centuries or that they were brought about by violent or spasmodic action. They were extremely gradual and protracted processes which took ages for their consummation. A hundred generations of living beings roll away before their effect becomes perceptible. Nature draws unlimited cheques on the Bank of Time.



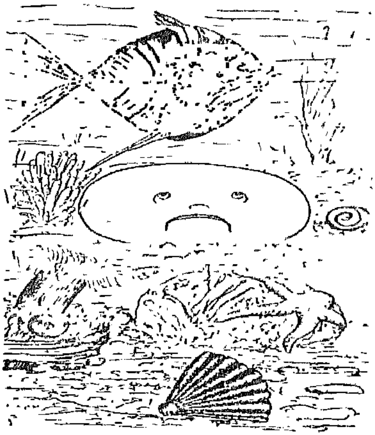
"Our time of trouble had begun. After the first flush of joy at our emerging into light and day we began to perceive our terribly exposed situation. Rain and frost, wind and cold, the insolation of day and night and of summer and winter, all these meteoric agencies began to tell upon the cohesion of the sandstone beds which composed the newly made land Time, the great agent of ruin, lent its insidious aid to these forces Percolating water, carrying with it dissolved gases from the air and acids from the ground, loosened and disengaged the constituent particles from one another and we soon saw every shower of rain that fell, after seasons of drought, carried away with it tons of sand and other disintegrated matter from us. Cracks and crevices appeared; they widened into fissures and admitted more air and water —the two chief agents in rock-decomposition into deeper parts. Another factor which helped in altering the surface was vegetation, which had taken hold on the ground and spread on it. While at first it seemed to protect the surface from the atmospheric wear and tear of the ground, by means of its various organic acids and the oxygen and carbonic acid gas of the air which were introduced into the subsurface by the mechanically penetrating roots and rootlets it produced a layer of rotted rock mixed with the debris of the vegetation,—the soil. This growing soil-cap by supporting vegetation more actively only accelerated a further disintegration of the layers deeper and deeper. Meanwhile the rains of all these ages had worked a marvellous change on the originally smooth, uniformly sloping surface of the ground. The precipitated water in descending to lower levels cut tunnels; these, gathering strength, had formed into streams, which joined to form rivulets. By wearing out the softer parts more readily than the harder, and by eating into the sloping parts more actively than the level tracts, it brought about great inequalities in the originally uniform surface. In what was once a level plateau, hollows and ridges, mounds and depressions, hills and valleys were carved out by the energy of the running water as by the chisel of a sculptor. Landslips were precipitated along slopes by the lubricating action of percolating water along crack-planes. Thus the denudation, by the atmospheric agencies changed the face of the new land and gave to it the ordinary worn aspect which is such a feature of land scenery in all parts of the world. Of course all this went on as the normal routine of Nature, taking vast measures of time and just as naturally as you now see things going on around you.

"In one of these land-slips I was thrown from a hill-side into the valley below. Thus detached from the parent home once and for ever, I lay in the fallen debris, a rough-hewn sharp-edged, massive block of sandstone, utterly unlike my present diminutive shape. Time rolled away. Torrential streams swept us along the river course. Each roaring debacle in rainy season carried us along with other blocks, knocking against one another and against the hard bed of the stream. Through new scenes and new lands we were rolled along and rubbed and scoured till even the hardest of us lost our original form and were reduced and rounded into boulders. Now stranded on some shingle bank, now dropped for a time on some sharp bend, now left high and dry for a long succession of rainless summers in the parched-up bed of the river, the ruthless transport continued. Eventually we reached the shores of the sea,- the great 'Tethys sea' of geologists, which stretched from the eastern extremity of the Himalayas to the north-west as far as the western limits of the Swiss Alps. There we were carried and dropped into its shallow waters, together with myriads of other boulders, pebbles, sand and other debris. Once more on the bed of the sea, we were cemented into the rock called conglomerate. Ages pass away, the great Tethys (as this ancient Himalayan sea is named) vanishes for a time and the rocks laid down on its bottom are uplifted and converted into dry land. Time and the weather again do their appointed task and after countless centuries we are once more set at liberty as loose stones and boulders, but only to be made again the sport of rivers and of the waves. Passing through these, we find ourselves once more on the beach of the Tethys which had returned to its former coasts after its temporary regression to the north. There, subject to the fury of the waves, hurled high in the air along their crests and rammed against the abutting cliffs, we worked our way once more beneath the water. Rounded by the constant rolling, reduced in size by the perpetual attrition, but otherwise unchanged, I yet held my own. But this ceaseless wear and tear had by this time ground into dust and sand most of my comrades. Thanks to the crystalline structure and inherent hardness of my grain, this fate did not befall me.

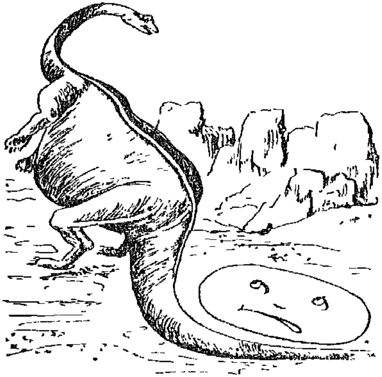
"Once more I became sealed up in a hard rock-bed. A great depression of the bottom of the Tethys commenced and continued for long periods which carried us some thousands of feet below the surface of the earth. A thick series of strata was deposited over the slowly sinking sea floor, and we lay in complete oblivion of everything in the deep plutonic regions of the earth's crust. Pressure and internal heat of the earth imparted to us a new grain and molecular structure. What vast aeons of time succeeded since I thus lay deep in the bowels of the earth, and what the history of the earth may have been during these epochs, it is not possible for me to tell. I can only say, that period was long enough for many widespread and striking changes to take place on the face of the globe—many lands with their highlands and mountains were denuded to their roots, many new rivers, valleys and lake-basins were formed, effaced and reformed ; the coast-lines of all the countries were changed beyond recognition ; in a word, the whole geography of the world was profoundly altered. In the learned language of Science, this era during which I lay *perdu* is known as the Mesozoic era of the Earth's history and represents the passing away of three great divisions of geological time—the Triassic, the Jurassic and the Cretaceous. The next succeeding era—the Cainozoic—was ushered in by a great reverse movement of upheaval of the sea floor, which put an end to the conditions of the Mesozoic times : the Tethys was driven back by the steady uprise of its bottom and finally obliterated, leaving behind only the modern Caspian and the Mediterranean as its shrunken relics. The strata were wrinkled and plicated into earth-folds by the gigantic up-thrusts which ensued. The forces of Pluto were gathered underground to produce the last and mightiest change on the face of our planet—the upheaval of the Himalayan chain of mountains on the site of what was once the bed of the Tethys. Scarcely was this revolution complete and the forces of Nature were settling down to their equilibrium, when the claw of the weather dug me out of the rock-bed, once again to play the part of a rolling stone and repeat my wanderings along the sea-beach or the river-bed. I will not tire your patience by detailing all my doings since then. Incessant and never-ending change seemed to be my destiny. The rolling, rounding and attrition, in rivers and torrents of the new mountains, went on, fitfully and with long pauses, till at length I reached the edge of the Himalayas. A broad estuary was then covering the site of the present Siwalik foot hills of the Punjab and among the deposits that were forming there (out of the debris of the newly risen Himalayas) I was dropped my last station and present resting place—at the identical spot you discovered me in.

"Thus I came to a brief respite from the wanderings of ages, but my journey's end was not yet.

"Amid all my peregrinations so far, since the infancy of the earth, what worlds of living beings both plants and animals, I have beheld! Let me tell you briefly of some of the more remarkable of these inhabitants that successively peopled the earth. In the early part of the narrative I have told you of the impoverished condition of the world when I was born in the era, known in Geology as the Paleozoic era. All the organic creation was then primitive, simple and generalised, in contrast with the varied and more specialised fauna and flora of today. In them, it almost seemed Nature had tried her 'prentice han'.' But as this time passed, new animals appeared and the older tribes died out, never again to appear. One notable feature of these successive creations was the progression from lower to higher types of animals as well as plants; species multiplied and the general total of life forms became more varied but less cosmopolitan. The first important advance, since my days, was the appearance of Fishes of a great variety of size and structure. They were quite unlike the modern fishes, and their curiously shaped bodies were encased in large plates of bone. Passing beyond the 'age of Fishes,' the next remarkable period—the Carboniferous period of geological history was one in which frog-like creatures appeared for the first time. The landscapes of the time were being rapidly changed now by the profusion of vegetable life, which flourished in rank abundance, thick matted jungles of fern and horsetail on every foot-breadth of the soil.



But from these woodlands anything higher than the seed fern type of vegetation was absent; their gloomy monotony being broken by huge frog like creatures—the highest class of animals then living—that hunted them. Their disproportionate and ungainly bearing ill suited their dignity as the monarchs of the animal world. This period of vegetable supremacy having closed with the Carboniferous, there next came a period in which enormous Reptiles were the order of the day. But of these times—the Mesozoic—I have no personal knowledge, being buried in oblivion deep under the bowels of the earth, as I have just said. My neighbour, this block of limestone, is of Jurassic limestone parentage and tells me the story of his times. He even possesses, entombed within him, many precious relics of the life of those days. In the air, on the land, and in the water there were reptiles of monstrous sizes and shapes. Those weird, uncouth giants then fulfilled by means of their various structural adaptations the offices now held by mammals. You cannot imagine a lizard as large as an elephant, yet the *Iguanodon* fully equalled, if it did not surpass, him in size. One singular creature—the *Plesiosaurus*—was truly the monarch of the seas. With the head of a crocodile it carried a neck which resembled the entire body of a python, a trunk like a bison, the ribs of a lizard and the paddles of a whale. A fish-like dragon, the dreaded *Ichthyesaurus,* more than 30 feet in length, traversed the depth of waters in search of food, that half killed its prey by the stony stare of its eyes, which were a full foot in diameter. Winged dragons, the *Pterosaurs*, careered through the air and filled the landscapes with their curious forms. The Jurassic and Cretaceous rocks of all parts of the world are full of proofs of what I say, for they contain enclosed within them the petrified bones and other remains of all these strange creatures.



"But before the Mesozoic era closed, this over-grown class of reptiles had all but passed away. The very advantages which gave them superiority over the other races in their day, viz., their large size and highly specialised organisation, unfitted them to withstand the rigours of altered circumstances which the succeeding age brought, and they lost in the keen race for struggle for existence against the less specialised but more hardy and agile races. Before they became extinct, a new and higher class of animals had emerged on the stage of creation, the class of

Birds Wonderful as it may sound, the birds originated directly out of the reptiles. First there were bird-like reptiles and then there came true birds but with several reptilian characters. The first such type that arose—the one known as *Archaeopteryx*, in the barbarous terminology of geology, had, instead of the graceful beak of the living birds, formidable jaws set with rows of sharp teeth, and possessed a long tapering tail like that of a lizard.

"Followed the Cainozoic era -the era of modern creation with many living orders of animals and plants, the era in which immense Mammals were the kings of the earth. The old-world families and orders of fishes, amphibians, reptiles and birds had become extinct and their place was taken by newer and more modern forms. The earliest progenitors of the mammals were the Marsupials and their allies. These early quadrupeds had combined in them characters and structural plans of many widely separated orders which were to come later in time Each succeeding epoch introduced new forms more and more like the living denizens of the world of today. The great carnivors, horse, pig, camel, elephant, rhinoceros, hippopotamus, cattle, deer, and ape came in due time : the grand march of life continued, till almost at the close of the era, came Man at the head of the procession, the last-comer on earth of all its animals. Man's entry on the stage of the world was co-eval with an extreme change in the climate. Sheets of ice covered the northern world, while even down to north Punjab, rivers of ice flowed down draining the vast ice-caps of the highlands. This refrigeration slowly culminated into an Ice Age for the whole of the northern world down to the latitude of 39 degrees, as the Himalayas completed their elevation. Then the ice slowly retreated and the climate became milder.

"In the preceding narrative I have given you a brief outline of my autobiography. My future I begin to perceive dimly, though yet in a far distant age. Do you hear the roar of the river water ? It is the requiem being sung by it as it carries many of my brethren to their doom —their dismemberment into fine impalpable silt. The same fate awaits me as sure as death. For look at the river-bed and you will discover what is going on there. Myriads of the boulders and pebbles from this place are torn from their site by its hundreds of tributaries in the monsoon, and are *being carried away grating against* one another and against the floor. They are pushed on till the burden is transported to the Jhelum, to undergo the same grinding; till the Jhelum in its turn transfers it to the Indus. There mingling with its own enormous load of sediment, washed away by itself and its hydra-headed tributaries from the uplands and plains of northern India, it is propelled onwards. Big boulders are reduced and rounded into small ones, these into pebbles, the pebbles are again ground into sand-grains and the sand-grains are still further reduced or decomposed into the finest particles of silt and clay. When the Indus's journey is finished, the whole freight is discharged at its mouth into the Arabian Sea, pebble, sand, and silt, there in its tranquil depths to rest for a time in horizontal sheets and layers on its floor. Out of these are formed the future sandstone, congolmerate and shales, the bricks and mortar of new lands. These will, on some distant day, be uplifted from their depths, and out of their ruins again, will be built newer lands, mountains and continents. Thus the process goes on in Nature in a never-ending cycle, decay and renovation succeeding one another as they have done again and again in the past, as this narrative of my humble—because of a mere stone's—existence has shown you."

Reader, in this story of the humble pebble of stone we have learnt some lessons in Geology, and got some insight into the hidden ways of Nature.

(P. S.—The pebble, the subject of the above narrative, is of white quartzite of older Palaeozoic age occurring in the Pir Panjal range of Kashmir. Such pebbles occur commonly in the Siwalik deposits (late Tertiary) of the Himalayan foothills along their entire length from the Punjab to Assam. —D. N. W.)

NUCLEAR REACTORS WHAT ARE THEY ?

Part I- THE BASIC PRINCIPLES

L. S. KOTHARI

University of Delhi

The first public announcement of the fact that man had discovered a hitherto untapped and very powerful source of energy, was unfortunately made in very tragic circumstances. On August 6, 1945, the U S. A. demonstrated the possibility of using nuclear energy in warfare by dropping a nuclear bomb (in common parlance called the atomic bomb) on the Japanese city of Hiroshima. This one bomb in which the explosive material was only about 50 kg., was equal, in explosive energy, to nearly 20,000 tons of a chemical explosive like TNT. Since then the U S. A., U. S. S. R. and U K. have tested hydrogen bombs which, in explosive energy, represent a thousandfold increase over the earlier nuclear bombs. The energy released in the first test explosion of a hydrogen bomb in March 1954, was larger than all the explosive energy released hitherto in war by man in his entire history. This tremendous difference between the energies released in the nuclear and chemical explosions is due to the fact that the sources of energy in the two cases are fundamentally different.

These days, in a number of countries, a lot of effort is being made at producing electrical energy from this new source and in a few decades a good fraction of the total energy consumed in any country may come from this source. It is therefore important to understand what this new source is.

WHAT IS NUCLEAR ENERGY ?

All matter consists of very tiny particles called *atoms*. An atom itself consists of a central, positively charged core called the *nucleus*, with negatively charged *electrons* revolving round it. The mass of the atom is almost entirely concentrated in the nucleus. The nucleus, in its turn, is composed of two types of particles, *protons* and *neutrons*. The protons carry a positive charge (equal in magnitude to that of an electron) but the neutrons are uncharged particles. Since an atom as a whole is electrically neutral, the number of electrons in the outer orbits is equal to the number of protons in the nucleus and this number is called the *atomic number*. The total number of particles, both protons and neutrons, in the nucleus is called the *mass number*. For a given atomic number one can have nuclei with different mass numbers and these are referred to as *isotopes*. Since the chemical properties of an atom depend on its atomic number, the various *isotopes* of an element are chemically indistinguishable.

Any particular isotope of an element is indicated by attaching the total number of particles in the nucleus (i e. the mass number) as a superscript to the chemical symbol. Often the atomic number, i e. the number of protons inside the nucleus is also indicated as a subscript either to the left or to the right of the chemical symbol. For example consider the two important isotopes of hydrogen, which are $_1H^1$ and $_1H^2 \equiv {_1D^2}$. These differ in the fact that the heavier isotope, $_1D^2$, usually called deuterium, contains one proton and one neutron inside the nucleus, whereas in the lighter isotope, $_1H^1$, there is no neutron in the nucleus. Water in which ordinary hydrogen ($_1H^1$) has been replaced by its heavier isotope $_1D^2$ is called *heavy* water. Another important example is that of the two isotopes of uranium, $_{92}U^{235}$ and $_{92}U^{238}$. Both have the same number of protons (92) but the number of neutrons are, respectively (235−92=) 143 and (238−92=) 146. Natural uranium is a mixture of nearly 99.3 per cent of $_{92}U^{238}$ and 0 7 per cent of $_{92}U^{235}$. The technological difficulty in separating $_{92}U^{235}$ from natural uranium (the separation requires physical processes) can be gauged from the fact that whereas the price of natural uranium is about Rs. 200 per lb, that of pure $_{92}U^{235}$ goes up to about Rs. 50,000 per lb.

A nucleus may be stable or radioactive, i.e. it may spontaneously give off an α-particle (Helium nucleus) or a β-particle (electron) and transform into a nucleus of some other element. Radioactive nuclei also emit γ-rays, which are analogous to very high energy X-rays. In a large dose all these radiations are harmful to life and may even prove fatal.

Apart from a few radioactive elements like radium and uranium which occur in nature, most of the others are produced artificially by bombarding stable nuclei with high energy α-particles or protons or neutrons. While studying the different nuclear reactions it was discovered that when uranium is bombarded by high energy neutrons something unusual happens. *A uranium nucleus breaks up into two nearly equal fragments releasing a lot of energy and two or three high energy neutrons.* This process of the splitting up of a nucleus into two nearly equal fragments is called *fission* The fission fragments are highly radioactive. The energy released in this process is so great that if a gram of uranium were fissioned completely the energy obtained would be about the same as got by burning a ton ($=10^6$ gm) of coal.

Soon after the discovery of fission, it was found that when very high energy neutrons (e.g. those produced in fission itself) interacted with U^{235}

nuclei, in the majority of cases this led to fission. On the other hand their interaction with the U^{238} isotope resulted in fission only in rare cases (in the majority of cases the neutrons are just scattered with a much reduced energy or absorbed to produce the isotope U^{239}). For slow neutrons the situation is very different. Though U^{238} absorbs these neutrons about just as well as it does the fast ones, the fission of this isotope by slow neutron is not at all possible. However, the absorptive power of U^{235} for slow neutrons is a few hundred times larger than that for fast neutrons, implying that slow neutrons are very much more effective in causing the fission of this isotope. In other words, if one could sufficiently slow down the fast neutrons (produced in the fission process) the chance of these neutrons causing fission of U^{235} would increase a few hundred times. One consequence of this is, that though in natural uranium the U^{238} isotope is about 140 times more abundant than the U^{235} isotope, it is the U^{235} isotope which absorbs slightly more slow neutrons than does U^{238}.

CHAIN REACTION

Since fission is caused by neutrons and in each fission process 2 to 3 neutrons are again liberated, the question arises if a mass of natural uranium can maintain a *self-sustained chain reaction*, i.e. if it can regenerate, in a given time, as many neutrons as are removed from the system by absorption or leakage.

The answer is—'No'. To maintain a chain reaction it is necessary that the number of neutrons causing fission should not diminish. Because of the presence of 99.3% of ${}_{92}U^{238}$ isotope in natural uranium, which absorbs neutrons but rarely undergoes fission, too many neutrons are removed from the system without creating new ones. There are two ways of overcoming this difficulty. One is to take a mass of almost pure ${}_{92}U^{235}$. However, if this mass is too small, a large fraction of neutrons may escape out of the system and too few may be left for absorption in uranium. Since one expects the fraction of neutrons absorbed to be roughly proportional to the volume of the system (assumed spherical) and the fraction leaking out to the surface area, we can increase the relative absorption by increasing the mass of the material. (The volume of a sphere increases as the cube of the radius whereas the surface area increases only as the square of the radius). The volume that will just sustain a chain reaction is referred to as the *critical size* and the corresponding mass of ${}_{92}U^{235}$ as the *critical mass*.

As mentioned earlier, slow neutrons are highly effective in causing the fission of U^{235}. In case one wanted to establish a chain reaction using natural uranium, the only possibility is to increase the relative effectiveness of U^{235} by slowing down the fast neutrons emitted during fission. When a high energy neutron collides with any nucleus, it loses some energy and the fraction of energy lost is inversely proportional to the mass of the nucleus. A neutron will, therefore, slow down rapidly by collisions with nuclei of low atomic weight, like those of H, D, Be or C. For example, a neutron on the average loses about $^{1}/e$[*] of its energy in a single collision

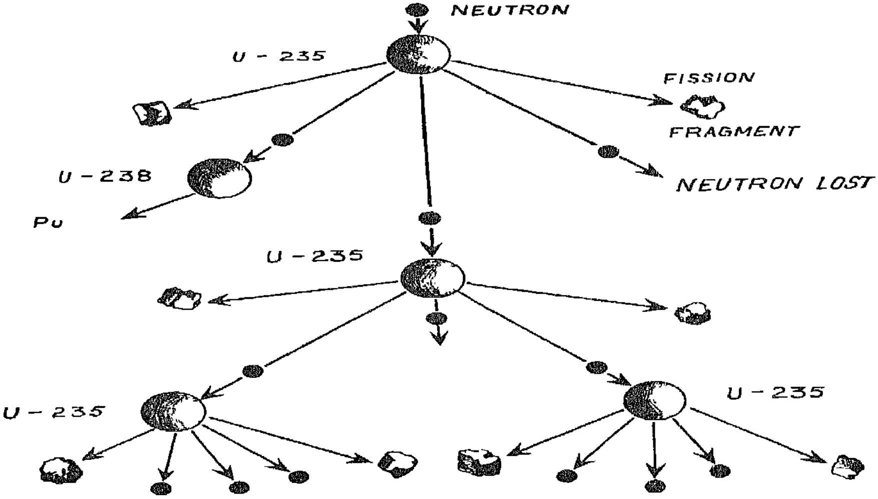


Fig 1 Chain Reaction

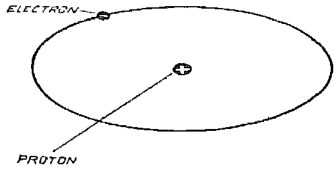


Fig. 2. (a) An atom of Hydrogen ($_1H^1$)

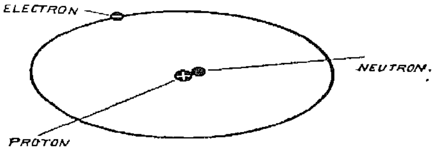


Fig. 2. (b) An atom of Deuterium ($_1D^2$)

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[*] e is a universal constant like π ; $e = 2.7183$.

with H; while in the case of carbon nuclei the energy of the neutron would go down by the same factor in 6-7 collisions. The medium which is used to slow down the neutrons is called a *moderator*. When neutrons have attained thermal equilibrium with the atoms of the moderator, they are referred to as *thermal* or *slow neutrons*.

Thus to get a self-sustained chain reaction with natural uranium one must have, in addition to the fissile material, uranium (also called *fuel*), some other material for slowing down neutrons i.e. a moderator. Any assembly of fuel and moderator (or for that matter an assembly of pure fissile material) which is capable of maintaining a self-sustained chain reaction is called a *reactor* or *pile*. It turns out that a homogeneous mixture of natural uranium and graphite will not sustain a chain reaction, whereas a suitable heterogeneous assembly will. Such an assembly is realized, for example, by having uranium rods embedded in a graphite block.

CRITICALITY CONDITION

Let us start with a thermal neutron. Suppose it is absorbed by a uranium nucleus. On the average more than one neutron must be produced in this process if the chain reaction is to continue. These neutrons are fast and will have to be slowed down. In this process of slowing there are a number of hazards that neutrons have to face. Some may be absorbed in the moderator, some may leak out and so on. If starting with one thermal neutron and going through the complete cycle we end up with k thermal neutrons, then the condition for criticality is obviously

$$k = 1.$$

If k is less than one, then the number of neutrons in the 'next generation' will be less than in the present generation and soon the reaction will die down. If k is greater than unity, the number of neutrons will go on increasing with succeeding generations and the reactor is said to be *supercritical*. Only when $k = 1$, the chain reaction proceeds at a steady and constant rate, since the number of neutrons in all succeeding generations would be the same as in any one generation.

To get a clearer idea of the relative importance of the various processes in a neutron's life-history we consider the following 'neutron balance sheet' for a graphite moderated reactor :

Average number of neutrons produced per fission of U^{235}	2.56
Neutrons absorbed in U^{238} by non-fission processes	0.9
Neutrons absorbed by moderator	0.3
Neutrons absorbed by structural material	0.05

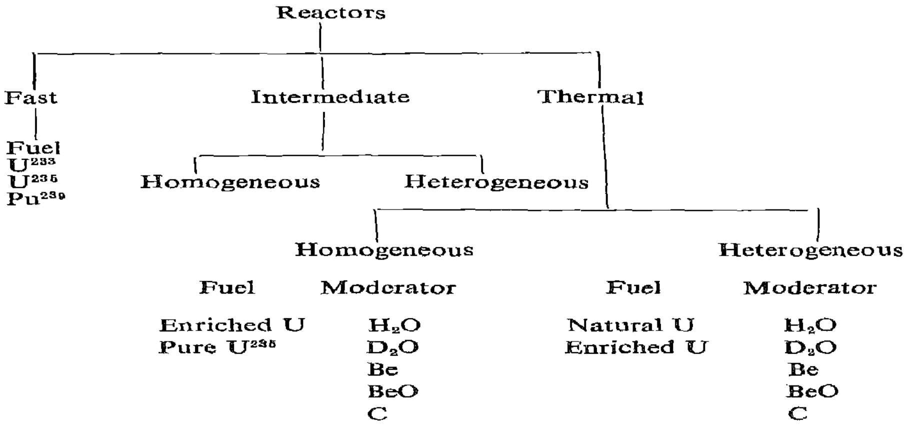
Neutrons absorbed in U^{235} in non-fission capture	0.2
Neutrons escaping from core	0.09
	1.54
Neutrons to maintain chain reaction	1.00
	2.54
Excess neutrons	0.02

The above numbers are for very pure materials and even in this case the excess neutrons are less than 1% of the total number of neutrons produced. It is therefore obvious that great care has to be taken in designing and building a graphite moderated reactor. A neutron absorbing impurity like boron, if present in graphite in such small traces as a few parts per million, would not permit the reactor to become critical.

The neutron balance sheet is much more favourable in the case of heavy water moderated reactors.

CLASSIFICATION OF REACTORS

So far we have talked of *three* possible types of reactors : (i) of a homogeneous mass of pure U^{235} and of natural uranium with (*a*) graphite or (*b*) heavy water as moderators. We now consider a more general question of classification of reactors.



All reactors can be classified broadly into three types (i) fast, (ii) intermediate and (iii) thermal, according to the energy of neutrons which produce the majority of fissions. One can further subdivide each of these classes into (*a*) homogeneous and (*b*) heterogeneous, according to the distribution of fuel and moderator in the system. The fuel used may be natural uranium, uranium enriched in U^{235} isotope, pure U^{235} isotope or even $_{92}U^{233}$ or $_{94}Pu^{239}$ (Pu = Plutonium). The moderator material may be graphite, light (or ordinary) water, heavy water, beryllium or beryllium oxide. Thus, for example, the first reactor we would call a fast homogeneous U^{235} reactor whereas the second one would be described as a thermal heterogeneous graphite moderated natural uranium reactor.

TABLE I (SOME ISOTOPES)

Element	*Symbol*	*Atomic Number* (*Z*)	*Mass Number* (*A*)	*Number of Neutrons* (*N*)	*Relative abundance in nature* (%)
Hydrogen	$_1H^1$	1	1	0	99.98
	$_1D^2$	1	2	1	0.02
Uranium	$_{92}U^{234}$	92	234	142	0.006
	$_{92}U^{235}$	92	235	143	0.7
	$_{92}U^{238}$	92	238	146	99.3

THE LIFE AND WORK OF NIELS BOHR

V. S MATHUR

University of Delhi

Since the time of Newton, our understanding of the physical world has undergone revolutionary changes. At the turn of the century, physics was in a fascinating chaos. More and more questions were asked for which the simple Newtonian mechanics had no answer. Blow after blow had shattered the foundations of our physical thought. Albert Einstein advanced his famous theory of relativity, which overthrew our age old concepts of space and time, and proved that matter is energy. On the other hand, Max Planck showed that the world of atoms did not obey the same laws as the physical world of our everyday experience, and thus ushered in the era of what we call the quantum theory. The synthesis of this new concept, and the development of the new mechanics was not the doing of any one man ; it involved the collaboration of scores of scientists. 'But', as Oppenheimer recalled, 'from first to last, the deeply creative, subtle, and critical spirit of Niels Bohr guided, restrained, deepened and finally transmuted the enterprise.' Niels Bohr has left an unmistakable imprint on the 20th century physics.

EARLY LIFE AND ACHIEVEMENTS OF BOHR

Niels Henrik David Bohr, was born in 1885 in Denmark. Even as a boy, he always wanted to be a physicist. In 1912, he went to Rutherford's laboratory in Manchester, England, just after Rutherford had explored the structure of the atom. Bohr, with his characteristic ingenuity, immediately developed a theory of the atom, which later on won him a Nobel Prize. In 1920, Bohr organised the University of Copenhagen Institute for Theoretical Physics, which quickly became a kind of scientific shrine, attracting the best students from all over the world. 'The unique and exciting feature of Copenhagen,' wrote Wheeler, one of Bohr's best students, 'lies in the stimulus that Bohr gives. I know of nothing with which to compare it except the school of Plato.' In 1939, just before the start of World War II, Bohr made a trip to the U.S A. He had just heard that some German scientists had split the uranium atom. This was atomic fission, and Bohr realized the danger if the Nazis were to build an atom bomb. He took this terrible news to the U.S.A., where the American scientists immediately repeated the experiments. Thus in America started the enormous Manhattan project for the construction of the first atom bomb, in which Bohr himself participated quite actively. Despite the fact that Bohr was directly connected with this project, for the rest of his life all nuclear weapons were objects of horror to him. His fondest hope was to find a way to abolish them. After the war, Bohr did extraordinary work to get European science on the track again. He pleaded tirelessly for peaceful uses of atomic energy and was one of the leading backers of CERN, Europe's cooperative research centre at Geneva. Honours were showered on him from all corners of the world. In November, 1962, he died of heart attack, and the world of science lost a deeply creative and guiding spirit

STRUCTURE OF THE ATOM A PLANETARY MODEL

Of the numerous failings of Newton's classical mechanics, the existence of the chemical elements with their individual properties, and their ability to form compounds could not be understood in classical physics. In 1911, Rutherford evolved from his classic scattering experiments, the planetary model of an atom. According to this model, an atom is pictured as having a central massive nucleus around which tiny, negatively charged particles, the electrons, are revolving, in much the same fashion as the planets revolve around the sun in our solar system. We know from Newton's laws, that if a particle moves in any path different from a straight line, it must be under acceleration. Further, like the antenna that emits radio waves, an accelerated charged particle, on the basis of classical physics, must emit radiation, and thereby lose energy. The electrons would then come closer and closer to the nucleus, and eventually fall into it. On the basis of classical physics then, an atom would be unstable, contradicting nature. Also according to classical theory, an electron in a given orbit should radiate light having either the frequency of rotation in the orbit, or else some harmonic of this frequency. If, for instance, the electron moves in a circular orbit with uniform speed, then only the fundamental should be radiated. However, the shape and size of an electron's orbit are continuously changing, so that, on the basis of classical physics, radiation emitted by an atom should have a continuous distribution of frequencies. Experimentally, however, it has been known for a very long time, that each atom emits only a discrete group of frequencies, which are characteristic of that atom. This is because each frequency leads to a corresponding line in the spectrum of the atom's radiation which is easily observable by a spectrometer. The result of classical physics is therefore in contradiction with well-known experimental facts. Thus classical physics provides no foundation to important subjects of chemistry and spectroscopy.

NIELS BOHR (1885-1962)

BOHR'S IDEA OF THE STRUCTURE OF ATOM

Within a short time of Rutherford's discovery of the planetary model of an atom, Bohr realized the inadequacies of classical physics. Already in 1900, Planck had found in studying an entirely different branch of physics, i.e. the equilibrium distribution of black-body radiation (e g., radiation trapped inside a chamber with no outlets), that the frequency distribution in such radiation does not obey the formula derived by classical ideas of continuous emission and absorption of radiation, but follows readily if we assume that radiation energy is emitted and absorbed in indivisible packets called quanta. The quantum aspect of radiation was subsequently emphasized by Einstein in working out the photo-electric effect, and by others in a number of instances where classical theory leads to wrong results. Bohr now took a bold step, and gave the revolutionary suggestion that even material systems cannot exist in any arbitrary energy state, which can be varied continuously, but must possess a discrete spectrum of energy levels. This means that electrons in an atom revolve in a few allowed discrete energy states, and cannot lose energy continuously as in classical physics. The orbit closest to the nucleus would then be quite stable. The discrete spectrum of atoms can be seen to arise in the following manner. If an electron of any atom is brought to a higher energy level, i.e. in an excited state, by supplying energy from external sources, e.g., as in a gas discharge tube, then since a system would like to exist in its lowest energy state, such an electron will eventually make a quantum jump to the next lower energy level, or to still lower ones, radiating light of frequency corresponding to the energy difference of the two levels in question. This would correspond to a discrete line in the radiation spectrum. In short, all lines corresponding to differences between discrete energy levels of the atom, which are characteristic of each atom, would be observed, giving rise to a discrete spectrum, in agreement with experimental facts. Bohr's idea can be transcribed into very simple mathematics, and calculations give an astounding quantitative agreement with the general features of radiation spectrum.

QUANTUM THEORY : 'COPENHAGEN SCHOOL OF THOUGHT'

Needless to say, Bohr's idea of quantization heralded a new era in scientific thinking. If quantization is at the root of the matter, what is the meaning of the classical concept of the path of a particle ? Thus, given the state of a particle at any instant of time, can we say with definiteness where the particle would be at any later instant ? It is clear that quantum laws appear to determine only the probability of an event, and cannot predict its occurrence with certainty. Thus, whereas classical theory is completely deterministic, quantum theory is not so in this sense. That the appearance of probability is not an expression of our ignorance or of the inadequacies of our detecting apparatus was first recognized by Heisenberg in his famous uncertainty principle. This principle of limited determinism in a broad sense states that nature is as deterministic as it could be consistent with quantum theory, and that the lack of classical determinism is an inherent property of nature. More specifically, it states, for example, that if the position of a particle is known at some time, then its momentum is entirely unknown at that time, so that the question as to where the particle would be at a later time is one which cannot be answered with definiteness, and one can only talk about the probability of its existence at any specified point. Such a probabilistic interpretation was heavily criticized when it was first proposed, and one of the heaviest critics was no less a person than Albert Einstein. The arduous task of clarifying and elucidating the philosophy of limited determinism in nature was undertaken by Niels Bohr. It is a glorious tribute to his depth of understanding and ingenuity of thought that not only did he succeed in disproving each of the paradoxes put forth by Einstein and others from time to time to thwart the probabilistic interpretation of nature, but he also showed that each of these so-called thought experiments is indeed an illustration of the basic uncertainty principle. Bohr's interpretation is widely acknowledged now, and it forms the basis of what is called the 'Copenhagen School of Thought'.

QUANTUM THEORY AND CLASSICAL CONCEPTS

An important question arises. How is it possible to reconcile these quantum ideas with our experiences in the realm of everyday world, where motion appears continuous, and can be described by deterministic laws, such as Newton's equations of motion ? The answer to this question was first given by Bohr in his famous correspondence principle. The apparent continuity of motion on a macroscopic scale is a result of the smallness of the quantum. In our everyday experience, we deal with processes involving many quanta, so that on a statistical basis, the discontinuity is so small that it is not observable. The correspondence principle states that the laws of quantum physics must be so chosen that in the classical limit, where many quanta are involved, the quantum laws lead to the classical equations as an average. The problem of satisfying the correspondence principle is by no means trivial. In fact the requirement of this principle plays a central role in the development of quantum mechanics. For instance, the quantization of angular momentum was first obtained by Bohr with the aid of the correspondence principle. This quantization is actually the basis of Bohr's theory of the atom mentioned earlier.

There is yet another important aspect in which quantum theory differs from classical concepts. This is the so-called wave-particle duality of matter and radiation. De Broglie was struck by the fact that radiation may be thought of as a bunch of quanta or wave-packets. This can be interpreted as radiation having a particle nature. Classically one knows, however, that light is a wave phenomenon essentially through the diffraction and interference experiments which cannot admit of a corpuscular interpretation. However, to explain a number of experimental results, e.g. the photo-electric effect etc , one is forced to introduce the quantum aspect of radiation, where we treat light as if it were made up of corpuscles. The question arises, what ultimately is radiation ? Is it a corpuscular or a wave phenomenon ? Furthermore, Bohr's idea of quantization of material systems, and the existence of a discrete set of allowed frequencies brought to De Broglie's mind the already familiar phenomenon in classical physics in connection with the motion of waves in an enclosure where standing waves have a discrete frequency spectrum. De Broglie speculated that material particles also possessed wave properties, obtaining in this way a unification between the properties of matter and light. Both could be different forms of some new kind of system that would act sometimes as a wave and sometimes like a particle. De Broglie's idea was experimentally verified soon after, when it was found that a beam of electrons is indeed capable of producing a diffraction pattern, when passed through crystals. However, the question whether matter and light are actually made out of particles or waves, Bohr emphasized, is a meaningless one. It is born out of lack of experience of any 'object' in our macroscopic world which comprises both these aspects. Bohr pointed out that the occurrence of wave and particle aspects is not contradictory but is indeed complementary. To know the 'object' completely one must know both its corpuscular and undulatory properties. However, these two properties are the extreme properties of the 'object' and cannot exist simultaneously, i e. if, we perform an experiment to test whether the 'object' is a particle, it invariably turns out that this indeed is the case (or else the experiment cannot be understood), but at the same time and by the same experiment we cannot and have no means to test whether it has any wave-like properties at all. To verify the latter, we have to perform a different type of experiment, but then we have no idea of the corpuscular aspect. Moreover, to know the 'object' *completely*, one has to add the informations of the two experiments. This is the essence of Bohr's principle of complementarity. Not only does this principle provide a great unification and understanding of the apparent wave-particle duality question, but it actually goes much further. It also embodies in its contents the uncertainty principle. For instance if we know the position of a particle within certain uncertainties, the uncertainty principle asserts that the momentum of the particle cannot be known at the same time precisely, but only within well-defined limitations. For a complete description we must know both of these limitations. The principle of complementarity thus represents not only a thorough-going change in the type of concept that is appropriate for the description of matter at the quantum level, as compared with the types of concepts at the classical level, but also synthesizes and provides a unified basis for some of the essential concepts of quantum phenomena.

NUCLEAR PHENOMENA AND BOHR'S ROLE

We have thus far explained in a simple way the central role that Bohr played in the development and synthesis of the unusual concepts of quantum theory. We see at once how Bohr sought harmony and simplicity in the complex phenomena of the microscopic world. The applications and interpretations of these concepts to the multifarious atomic and nuclear phenomena is yet another long story. The contribution of Bohr here again has been no less important. We would like to present here a few examples which reveal an insight into his originality and simplicity of thought, an underlying feature of Bohr's life and work.

Ever since Rutherford split the atom, physicists have been studying nuclear reactions, i.e., what happens if we shoot an elementary nucleus on to another complex one. The fragments of the collision can be various types of nuclei, generally an elementary one and a complex one. For any given energy of the projectile, one can only calculate the probabilities of the various reactions. However, at some definite energies, it has been observed that a particular mode of fragmentation becomes much more likely than the others, giving rise to the phenomenon of resonance in that mode of reaction. Indeed several such resonances have been found in any general nuclear reaction. The study of such reactions was greatly facilitated by Niels Bohr, who put forward the extremely simple, yet effective, concept of the compound nucleus. According to this idea, when the projectile hit the target nucleus, they coalesce into a compound nucleus, which subsequently breaks up to produce the reaction products. Bohr argued that nuclear interactions, unlike any other well known form of interactions in our macroscopic world, are very strong, so that the capture of the projectile by the target nucleus to form a compound nucleus is a very likely process. When the projectile hits the target nucleus, it distributes its energy very rapidly in the collision, and does not possess enough energy afterwards to break loose from the strong attractive nuclear forces. A statistical equilibrium is reached, and until such time as a chance accumulation of sufficient energy on any particle of the nucleus, the compound nucleus continues to exist. The compound nucleus is then fairly long-lived (compared to nuclear time

$\sim 10^{-21}$ seconds), and by the time it finally breaks up, it has forgotten how it was created. The decay mechanism is then quite unbiased by the mode of formation of the compound nucleus. Experimentally such is indeed the case, and the compound nucleus picture then forms a very convenient basis to study nuclear reactions. The phenomenon of resonance can also be very simply understood as follows. The compound nucleus exists only in well-defined quantized energy states. If the projectile possesses energy that just matches in value with that of one of the quantized energy states, the capture of the projectile takes place quite readily, giving rise to the phenomenon of resonance. At any other energy of the projectile, it has to share energy in such a way that it can finally find a place in one of the quantized energy levels of the compound nucleus, so that the capture does not take place so readily. Actual calculations based on this model have led to results in excellent agreement with the general features of nuclear reactions.

As another illustration of Bohr's simplicity and ingenuity of ideas, let us consider the liquid drop model of Bohr in the theory of nuclear fission. In playing around with nuclear reactions, it was observed that if a neutron hits a very heavy nucleus, e.g. U^{235}, then the decay products are not simple, as in nuclear reactions, but consist of two almost equally massive complicated nuclei. This is called the phonomenon of nuclear fission. The original nucleus U^{235} breaks up into two almost equal lumps. The importance of this phenomenon cannot be over-emphasized. During fission a tremendous amount of energy is produced which can be harnessed as in a nuclear reactor, or which can be used for destruction as in an atom bomb. This seemingly complicated phenomenon which baffled physicists for some time, was shown by Bohr to have an extremely simple explanation. Bohr noticed that a nucleus has many properties similar to a liquid drop. Firstly, it is known experimentally that the size of a nucleus is proportional to the cube-root of the total number of particles inside the nucleus. Since the mass of the nucleus is proportional to the total number of particles also (each particle having the same mass), it follows that the density of nuclear matter is constant, and does not depend on its size. This is indeed a property of a liquid drop also, as is quite well-known. Secondly, the energy that keeps the various particles in the nucleus, bound together, i. e. the binding energy is known experimentally to be proportional to the total number of particles in the nucleus, just as in a liquid drop the various molecules of the liquid are bound by forces proportional to the number of molecules. Thirdly, both nuclear matter and liquid drop exhibit the phenomenon of surface tension. The observation of surface tension in nuclear matter comes from the fact that the binding energy per nuclear particle, which we said is a constant, is actually found to decrease in magnitude for light nuclei, an effect which will be large for nuclei with high surface-to-volume ratios. Finally, thermal agitation of molecules in a drop has a counterpart in the kinetic energy of nuclear particles. There are some obvious differences of course. The nucleus obeys quantum laws and one should strictly liken it to a drop of 'quantum' liquid. Despite this, we may describe the dynamics of a nucleus in terms of surface vibrations. A deformation of a spherical drop gives rise to periodic oscillations of the surface. The fission process can now be understood in a naive way as follows : a large liquid drop (the U^{235} nucleus), when set into oscillations by an external stimulus (the neutron), will split into two drops of roughly equal size. A detailed calculation based on this model indeed gives excellent agreement. As to why for example, U^{234} is not fissionable by neutrons, whereas U^{235} is, requires a slightly more complicated explanation The important point that answers this question is whether the excitation energy associated with the oscillations is less than or greater than the so-called activation energy, i.e. the energy required to create fission.

Many of Bohr's important contributions to physics, have not been included in this simple-minded article. It is nevertheless quite clear that in the seemingly complicated phenomena of the microscopic world, Bohr sought simplicity and harmony in nature. It is to this belief and faith that Bohr dedicated his life and work.

GOVERNMENT, SCIENTIFIC AND TECHNICAL DEVELOPMENT IN EMERGING COUNTRIES*

P. M. S. BLACKETT

Imperial College of Science and Technology, London

I intend to speak about the problems of formulating practical and realistic plans for the application of science and technology by the Government of a newly emerging country. I will specifically have in mind the new African nations, since, for various historic reasons, their problems are particularly difficult.

The first thing which must strike, say, the Prime Minister or Minister of Finance of such a young nation, is that science and scientists are expensive and that their financial demands clash with the innumerable other demands on a country's very limited financial resources, and still more limited foreign currency. Even in the field of scientific and technical education alone, there will be the choice to be made of the proper relation between primary, secondary and higher education ; or between training science teachers, scientifically trained administrators, research workers in pure and applied science, and engineers and technologists. Then there are of course, essential problems as to what researches should be carried out and for what purpose. It is important to note that these main decisions have to be made by the Government. For the Government alone, in general has the financial resources to carry out any worthwhile programme. Even when financial aid from other countries is available for specific educational and scientific projects, government assessment and approval will generally be necessary. It is interesting to remember that the present situation of the young nations, where the main responsibility for making decisions must rest with the Government, was not true of the emerging stages of development in Europe and the U.S A. In those days private initiative and benefactions played a vastly bigger role than they possibly can do today. So it comes about that today a great deal of very detailed decision-making in the scientific and technical field will fall on the governments of these newly emerging countries, and just at a time when vital political, economic and social problems have to be solved. It is evident that a high priority for the educational system of an emerging country is the training of an adequate number of scientifically and technologically minded executives, able to make these complex and difficult decisions.

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* Address delivered at the Science and Technology Conference, Geneva, in February 1963.

Any Minister or other high official from an emerging country who is attending this great conference will, no doubt, be in two minds about the vast display of scientific and technological developments which are dealt with in the thousands of communications. On the one hand, the conference will make clear the great possibilities, inherent in modern scientific industrialisation and agriculture, for the raising of the material standards of life of the emerging countries. On the other hand, it will confront such a statesman or official with a frightening number of decisions which must be taken. For, even leaving new research and development out of account, the sheer bulk of advanced technology which is available to be bought in the world today, by a nation with the cash, is staggering. Even rich countries like the U. K. do not buy every process, plant, machine tool or vehicle on sale : nor can it afford to engage effectively in research and development in all the fields which are to be discussed at this conference. How much more must this be true of the newly emerging countries, with their very limited resources both of finance and of trained manpower ! Their representatives here today may feel like window-shoppers, admiring the riches of modern technology through the plate glass window of their limited resources in money and men. Moreover, when they have some money in their pockets they must clearly be very discriminating purchasers.

In considering the formulation of national policy in relation to modern science and technology, it is useful here to distinguish four main aspects.

The first is that of known and available technology. Most of the most urgent needs of the emerging countries in the early stages of development come into this category. To set up a motor bus service, it is necessary to have the foreign exchange to buy the vehicles and fuel, and the technical schools to train the drivers and repair personnel, but no research or development at all is needed. Nor is new research and development required to set up an airline ; or a television system ; or an elecricity supply, or a sewage system and piped water supply, or the majority of normal manufacturing plants. Though such projects do not involve any appreciable research and development they do require an adequate supply of technically and scientifically trained personnel to run them.

A big increase of indigenous-trained scientific, technological and administrative personnel will be needed before a country can make full use of the known technologies without the very expensive and often politically undesirable undue reliance on foreign personnel. A major task of a new nation's educational system must be to provide as soon as possible the necessary technological intelligentsia to make use of all the known and available technology which the country can afford to buy. Prominent among the vital tasks, which such trained people will have to tackle, is the formulation of sensible 'shopping list'—I mean by this homely phrase the decision as to what to buy and what not to buy in the world's well-stocked supermarket for production goods and processes. In one sense this great conference is a catalogue of what is available, and so should be of great value to the citizens of the emerging countries who have the responsibility for making these decisions. One cannot overemphasize the importance of recognising the necessity for wise choice of what to buy. The mere reading and digesting of the mountainous mass of the conference documents will provide a major task for the scientists and engineers of the emerging countries.

The second most important aspect of the application of science and technology to a less developed country is that concerned with problems which are related to the special conditions of the country, and the solution of which must be done on the spot. Prominent among these, of course, are those special aspects of agriculture and medicine which have specific local significance. Then there are many problems in meteorology, geology, geophysical surveying, road building and housing where original research and development related to local conditions is required. In addition, many new technological problems arise in the setting up of local industries, due to the special properties of the local fuels, raw materials, textiles, food stuffs, etc.

In relation to these problems, the importance of a first rate information service is vital. It must be made as easy as possible for the research and development personnel to be kept continuously aware of the state of general world knowledge on a particular subject, so as not to be led by ignorance into expensive researches to find out what is already well known. The opposite danger is to assume too easily that some process, technique or method, which has long been in successful use in some other country, can be transferred without modification to new surroundings. Some of the most valuable research projects in the early stages of a country's development will surely lie in the imaginative adaptation of known methods to local conditions.

Many of the medical problems are of such importance that international co-operation is essential. Many of the specific diseases of tropical countries, for instance, are common to many different new nations. Moreover, the problems are often far too difficult to be tackled except by strong and experienced research teams. Where Inter-Territorial Research Institutes studying these problems already exist they should be more strongly supported, and should receive what help they need in personnel from the already developed countries. Where they do not exist, new ones should be started.

There is one ever imminent danger in such fields as medicine and agriculture. This is, that the policy-makers may become so impressed by the latest triumphs of science that the more humdrum requirements of public health and good husbandry may get too little emphasis. The danger of relying on wonder drugs and neglecting the plumbing is very real. Historians of the future may be amazed that our present epoch had the genius to discover penicillin, but had not the wit to give more than a fraction of manhood sewage system up to the technological level of Mohenjodaro, 5,000 years ago.

The third aspect of the agenda of this conference, is the group of new technologies which are not yet in use anywhere, but are still under development mainly in the technologically advanced countries. I refer, for instance, to such things as solar heat, fuel cells, de-salination of water, and hosts of improved processes and manufactured goods. Though a close watch must be kept on these developments, I am convinced that the national economic and technological planning of a new country's development, over the next decade or so, should be based on what is now known. Useful technological innovation, when it arises, should be welcomed as a welcome windfall profit : it should not be relied on for planning purposes. In fact, most of the now emerging new technologies are likely to be of only marginal economic importance to those countries, which are in the early stages of development, compared with the possible gains from fully utilising existing technologies. For often, but not always, new development like nuclear power, de-salination of water, etc. are expensive in capital cost— and it is capital, particularly in the form of foreign exchange, that emerging countries tend to be most short of. It is essential that the applied scientist and technologist of the emerging countries develops a sound sense of the economic realities of the related phases of research, development and production. Only when the last stage of production is reached does any advantage accrue in the form of increased material wealth. Though no one would admit to believe that modern science is a magic wand to be waved over a poor country to convert it into a rich one, not a few seem to act as if it were true !

One technological task which might be given more attention, both in the developing and developed countries, is the production of medium or small scale manufacturing plant and processes which have a lower capital cost per unit of output even though the labour cost is higher. It is to be remembered that most of the production goods on sale in the world supermarket have been designed primarily for advanced countries, where capital and transportation are cheap and labour is expensive. In most developing countries on the other hand, capital is necessarily in short supply, transport is inadequate and in many areas labour is plentiful at any rate seasonally. I am glad to see a number of contributions to this conference, which deal with certain aspects of this problem.

The last aspect of science and development in an emerging country which I want to touch on is the vital problem of the role of pure research, unrelated to the immediate economic and social needs of the country. In my view a limited amount of such work by the ablest scientist is vital to the scientific health of the country and should whenever possible be carried on in close relation to the Universities. Thus each new generation of students will come under the influence of the nation's most creative scientist. Experience has shown the great mutual benefit of such a close link between research and teaching. An adequately staffed undergraduate department and a substantial post-graduate school is an essential requirement for worthwhile University research. In my view it should be a major aim in the developing countries to bring into being, as soon as possible, at least one flourishing graduate school of research in each of the main scientific and technological disciplines. When this is achieved, it will no longer be necessary to send most of the best graduates overseas for post-graduate study—at great expense and with the expectation that many will not return It is probably wiser in general to send the students abroad only after their Ph. D. and when they have already been appointed to permanent posts.

What is certain is that the degree to which a developing country can realise the potential wealth, latent in modern science and technology, depends both on money and trained manpower. Without adequate supply of both, an emerging nation will inevitably remain a window-shopper.

A STUDY OF WATERBIRDS

The Science Club attached to the Extension Services Centre, St. Christopher's Training College, Vepery, Madras, undertook a study of the waterbirds of a neighbouring bird sanctuary As a result of their observation the members brought out a booklet to serve as a guide to know these birds. The following article is extracted from this booklet. We are sure that similar studies could easily be taken up by other Science Clubs with great profit to its members.

INTRODUCTION

Vedanthangal is a village in Chingleput district in Madras State, about 85 kilometers (or 53 miles) from Madras, by road. This spot has been declared as a sanctuary by the Government and gives protection to the water birds that frequent it. The sanctuary is a small tank of about 74 acres with an island in the middle with over 500 Indian Oak trees, which have the capacity to withstand waterlogging for long periods. The island with the trees gives protection to birds from predatory reptiles, smaller mammals, monkeys and men. When the tank gets filled with the onset of the North-East Monsoon, it is about 15 feet deep in the middle and abounds in aquatic fauna and flora. The birds feed on the aquatic insects, worms, snails, tadpoles, frogs and fishes, tender shoots, flowers and seeds of water-plants. The trees offer very favourable conditions for nest building.

Several thousands of birds take protection in the sanctuary. The early arrivals, usually the Openbills and Herons, settle down on the central trees. The late arrivals like the Cormorants and Egrets occupy the periphery. On the Western side of the tank is a bund that runs for nearly 400 yards and provides a raised balcony from which visitors can watch the birds.

It is only the water birds that are attracted to this sanctuary and gain its protection. Of course, this does not mean that other birds like the common crow, parakeets, kites and king-fishers are absent. What is most remarkable is that the sanctuary draws together over 14 species of water birds all nesting and living together in close proximity.

The best months to visit the sanctuary are November, December and January. During the other periods of the year the bird population is very much depleted.

The best time to observe the birds is either the morning, when they leave their nests to wander out in search of food, or the evenings when they return in flocks. It is better to observe the birds of this sanctuary in the evening as the sun does not fall on the observer's eyes as one looks from the bund on the western side. Between 6 and 6.30 p. m. the birds can be seen arriving in formations silhouetted against the blue sky. Day feeders like the Egrets, Cormorants, Openbills, and Ibises return home and the night feeders like the Night Herons, and Spoonbills start out on their hunt.

WHITE IBIS *(Threskiornis melanocephala)*

These large birds can be recognised by their long curved and sickle-shaped black bills. The legs, head and bill are black, but the body is white. They are nocturnal feeders. Their nesting season is from November to February. During the breeding season they develop plume-like feathers on the bases of their neck and breast.

The birds are also found widely distributed in other parts of South India, chiefly in the larger marshes where wider areas of water are covered with bushes and trees. They are usually found in small groups associated with other ibises and storks. They feed upon aquatic insects, worms, frogs, snails and crabs. Their nests are built of sticks and 2-4 eggs are laid which are bluish or greenish-white with or without yellowish-brown spots on the surface.

SPOONBILL *(Platalea leucorodia)*

The Spoonbills are readily identified by their spatulate or spoon-shaped bills which are used for shovelling into the mud in search of insects and worms. The birds are tall, white, with black spoon-shaped bills tipped with yellow. The legs are black. They arrive in Vedanthangal sometimes in breeding plumage, with a crest of feathers on the back of the head They also breed at Vedanthangal, the nesting season being November or earlier.

These are semi-nocturnal feeders, chiefly depending on tadpoles, frogs, snails and other aquatic animals. Their flight is slow with a steady wing stroke. They fly with the neck and legs extended. The young ones possess bills of the ordinary type which get moulded into the spatulate shape as the birds grow older. They build a platform of sticks for a nest and normally lay 4 eggs—white and spotted.

OPENBILL STORK *(Anastomus oscitans)*

These are the smallest members of the family of storks, which can be easily identified by the ugly gap in the reddish black bills. The body is greyish white with a fringe of black on the wings and tail. The legs are pink.

They are common birds seen in small groups They produce a clattering noise with their bills, that could be heard from a considerable distance. They fly with the head and neck extended. Their main food is water snails, but small crabs, frogs and fishes are also eaten. Their breeding season is November to March. They build a platform of sticks with a depression in the centre and lay 2-4 white eggs. It is interesting to note that the young do not exhibit the gap between the bills.

CORMORANT *(Phalacrocorax)*

These medium-sized birds of about the size of a domestic duck can be readily recognised by their black or dark grey coat of feathers, and by the beaks which are hooked at the tip and the long stiff tail. They are good swimmers and divers and their chief diet is fish. While swimming, only the head and the neck are visible above the water level. These birds are essentially residents of Vedanthangal, very abundant all over South India, occasionally found fishing on the sea shores, although they prefer fresh-water marshes and tanks. They breed during November to February; construct a shallow platform of twigs like that of a crow's nest and lay 4-5 pale bluish-green eggs. The three common species of Cormorants are:

1. The Little Cormorant *(Phalacrocorax niger)* about the size of a crow and most numerous at Vedanthangal.
2. The Shag *(Phalacrocorax fuscicollis)* which develops a white patch near the ears during the breeding season.
3. The Large Cormorant *(Phalacrocorax carbo sinensis)*, rarely seen at Vedanthangal; exhibits a yellow skin on the face and throat.

DARTER or SNAKE BIRD *(Anhinga rufa melanogaster)*

The Indian Darters are about the size of a duck and can be easily recognised in the field by their very long slender 'S' shaped neck, a feature which has earned for its possessor the common name 'snake bird.' They have silver grey streaks on the black body and long stiff tails. The bills are also long and pointed like daggers. Their chief food is fish and the dagger-like bill is shot at the prey with lightning rapidity, and later the fish is thrown into the air and caught between the open bill and swallowed.

They live in perfect harmony with Cormorants, Herons and other water birds. They breed during November-February and construct a flat platform of twigs and lay 3-4 eggs which are elongated in shape and pale greenish-blue in colour.

LITTLE EGRET *(Egretta garzetta garzetta)*

These are snow-white birds about the size of a large hen. They possess black bills and black legs with a yellow patch on the feet, and look most elegant in the breeding season when they develop long drooping crests of narrow feathers on the head and finely branched ornamental feathers on the breast and back. These are the 'aigrette' feathers of commerce which once fetched a high price in the market. They wade in shallow waters or walk about on soft mud in search of insects, frogs and small animals that form their diet. They build nests very much like those of the crows, but lined with straw and leaves. They sometimes select trees away from the water. Usually four bluish green oval eggs are laid.

Two other related egrets, the Median Egret (*Egretta intermedia)* and the Large Egret *(Egretta alba)* are also seen. The former has a yellow bill that turns black during the breeding season and lacks the yellow patch of the legs, and the head plumage of the Little Egret. The Large Egrets are solitary birds, rarely seen in the sanctuary, with their rich yellow bills and black legs and feet.

PADDY BIRD or POND HERON *(Ardeola grayii)*

These are white birds about the size of a hen clothed with a protective coat of brown mantle. The legs and feet are greenish yellow. They sit crouching with the neck completely retracted between their shoulders. In flight, the white wings and tail become more conspicuous. During the breeding season they develop special plumes on the head and a maroon plumage on the body. Their chief food is frogs, fishes and aquatic insects. They breed during November to January and lay 3-5 pale greenish blue eggs in their nest of twigs.

CATTLE EGRET *(Bubulcus ibis coromandus)*

This bird, about the size of a Little Egret, is dirty white in colour and its bill remains yellow all the year round. The feet and legs are dark. The birds move about in groups and are usually found in the company of grazing cattle. Their chief diet is insects and they sometimes help the cattle to get rid of their external parasitic insects and ticks. They breed during November to December, build nests away from the water and lay 3-5 eggs.

GREY HERON *(Ardea cinerea rectirostris)*

This is the common heron about the size of a small stork. Body is ashy grey with a long 'S' shaped white neck and head. The head bears a crest of long black feathers, and a conspicuous black dotted line can be seen on the side of the neck. The legs are yellowish pink and long. The Grey Herons are mostly seen in the company of Openbill Storks. When frightened they assume rigid postures extending the neck. They are partially nocturnal, feeding in the evening twilight or early morning. Their chief diet consists of fishes, frogs and other aquatic animals. During flight the head is drawn between the shoulders. Three to six eggs are laid in a nest of twigs, the breeding season being November to March.

NIGHT HERON (*Nycticorax nycticorax nycticorax*)

These birds are about the size of a kite, but with a more compact body and a characteristic hunchback. They are ashy grey above with a glistening black back with a green metallic sheen. The black head bears a crest of long plumes. The underside of the body is white. By their colouration they are well camouflaged among foliage. They are night feeders, leaving the nest at dusk in search of food—chiefly insects and fishes. They breed during December to February and lay 4-5 green eggs in a nest of twigs.

PELICAN (*Pelecanus philippensis philippensis*)

This large bird with its enormous beak and elastic pink pouch on the lower jaw is very rarely seen at the sanctuary. The body is pinkish below and grey above. The Pelicans' chief diet is fish. They hunt after fish in an organised manner driving the shoal and catching them with a scoop of the lower jaw bearing the pouch. They are migratory in habit. The upper bill shows large spots and so this species is called the Spotted-bill or Grey Pelican. The breeding season is from November to April when they lay three white eggs in a nest built on trees.

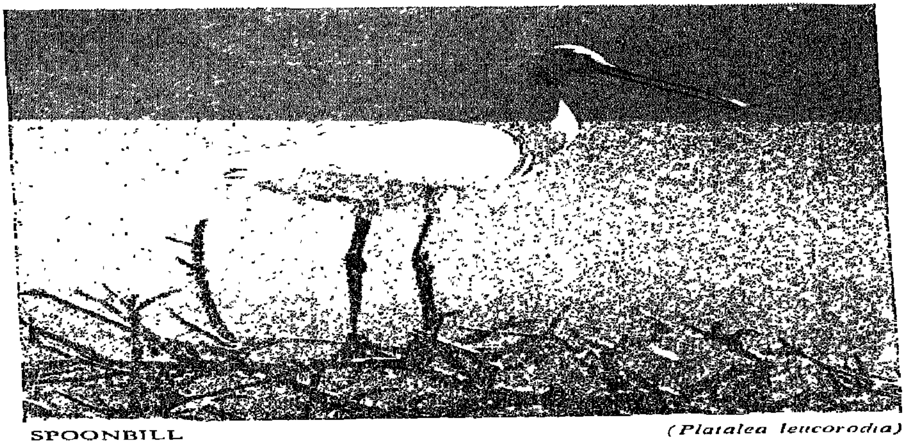
LITTLE GREBE or DAB CHICK (*Podiceps ruficollis capensis*)

This small bird, about the size of a pigeon, looks like a tail-less ugly duckling with a compressed and sharply pointed bill. The body above is dull coloured, but the underpart is silky white. The Dab Chicks are highly specialised for life in water, the feathers being silky and water proof. They rarely set their foot on land. Their chief food is insects, and other small water animals. They build a nest on floating vegetation and lay 3-5 white eggs during May to November when they breed.

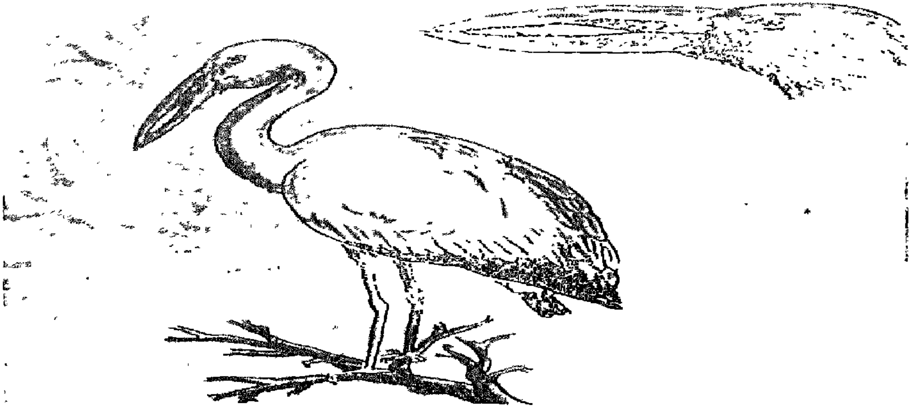
GREY DUCK or SPOTBILL (*Anas poecilorhyncha poecilorhyncha*)

This large duck can be recognised by its black bill, with a yellow tip and two orange spots at its base. The chest and the lower part of the body are white, spotted and brown. The legs are orange-red. The spotbills feed on worms, insects, grains and other vegetable matter. They breed during June to September and construct a nest in the hollows of trees and lay 8-12 or more eggs.

WHITE IBIS *(Threskiornis melanocephala)*

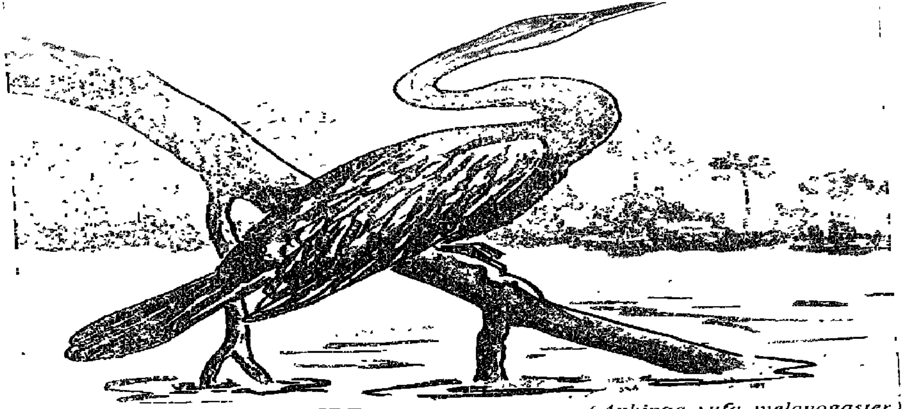


SPOONBILL *(Platalea leucorodia)*



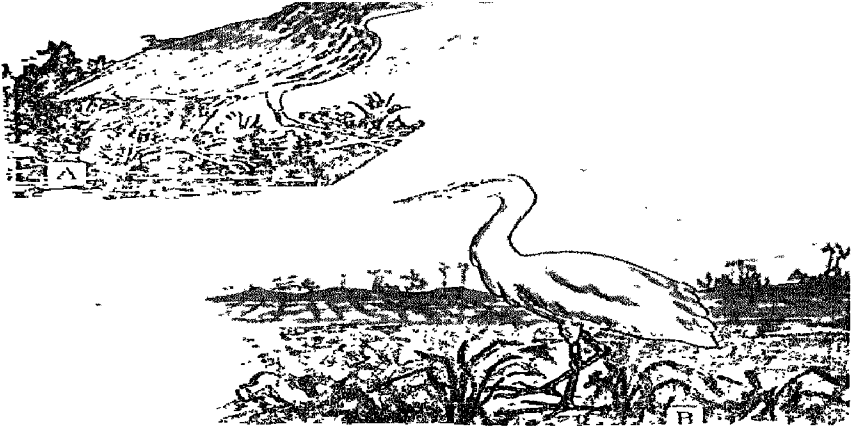
OPENBILL STORK *(Anastomus oscitans)*

CORMORANT *(Phalacrocorax)*

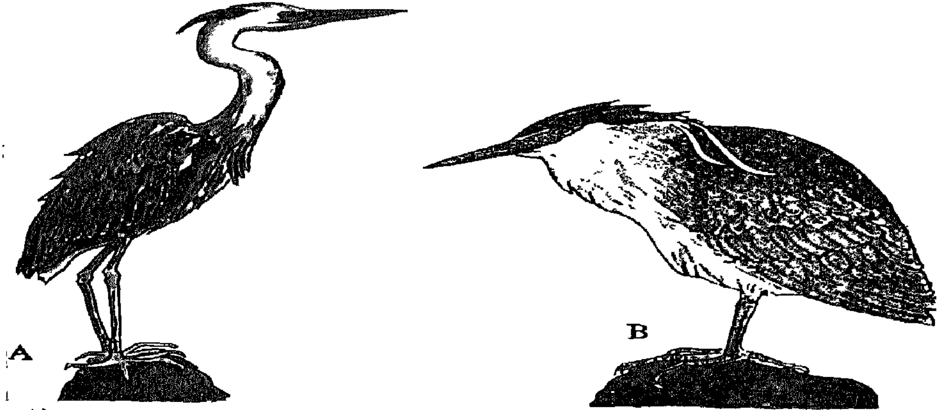


DARTER or SNAKE BIRD *(Anhinga rufa melanogaster)*

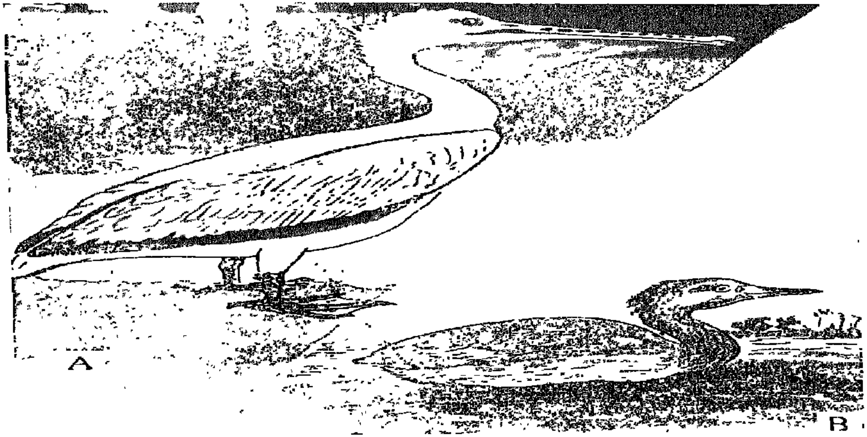
LITTLE EGRET *(Egretta garzetta garzetta)*



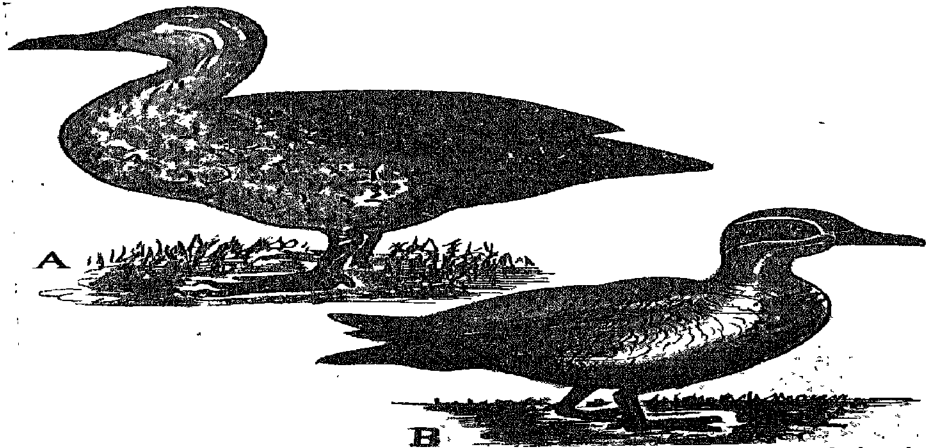
(A) PADDY BIRD or POND HERON (*Ardeola grayii*)
(B) CATTLE EGRET (*Bubulcus ibis coromandus*)



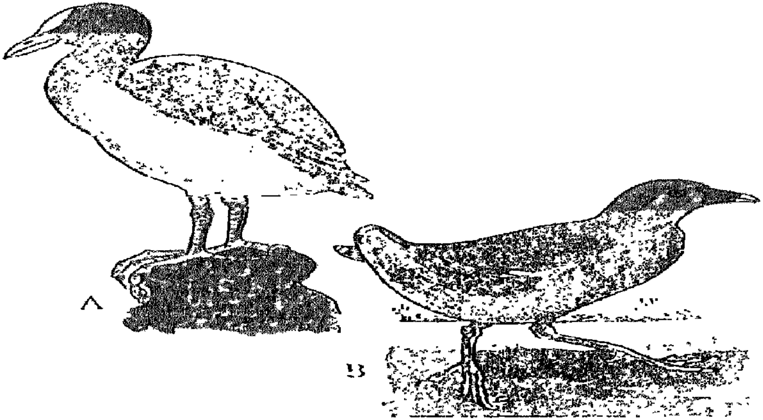
(A) GREY HERON (*Ardea cinerea rectirostris*)
(B) NIGHT HERON (*Nycticorax nycticorax nycticorax*)



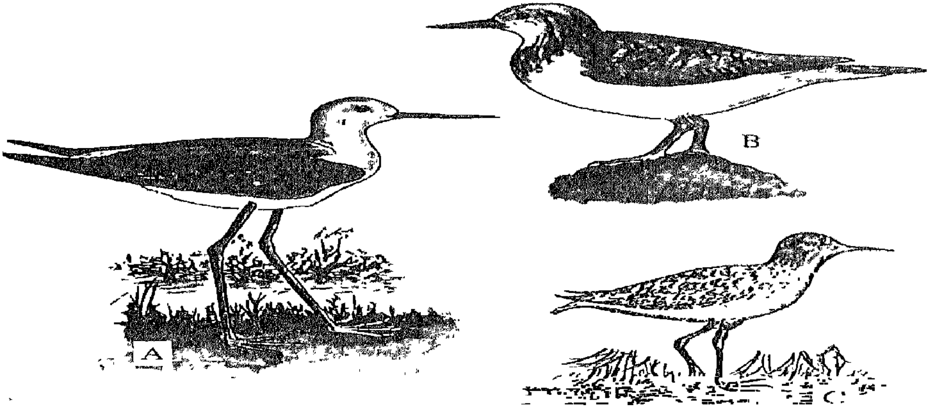
(A) PELICAN (*Pelecanus philippensis philippensis*)
(B) LITTLE GREBE or DAB CHICK (*Podicepes ruficollis capensis*)



(A) GREY DUCK or SPOTBILL (*Anas poecilorhyncha poecilorhyncha*)
(B) COMMON TEAL (*Anas crecca crecca*)



(A) COOT (Fulica atra)
(B) MOOR HEN (Gallinula chloropus indica)



(A) BLACKWINGED STILT (*Himantopus himantopus himantopus*)
(B) SAND-PIPER (*Tringa hypoleucus hypoleucus*)
(C) LITTLE STINT (*Calidris minutus*)

COMMON TEAL (*Anas crecca crecca*)

These birds are the commonest of the migratory birds in India. Their native home is northern Europe, eastern Siberia and Russia where they breed during April and June. They lay 8-12 cream-coloured eggs in a nest of grass and weeds. When winter sets in, they migrate south, and sometimes, can be seen at Vedanthangal in large numbers. These members of the duck family wear a grey plumage. The males are more beautiful possessing a metallic green band running through the eye, bordered by a white line. There is also a patch of green and black in the wings. The female is darker. They feed mostly at night on tender shoots of marsh plants, snails, worms, crabs and insects.

COOT (*Fulica atra*)

This bird is a native of India—and breeds near the Himalayan range and migrates south in winter. It is about the size of a hen, slaty black and without a tail. The bill and forehead shields are white and their toes are frilled. The Coots are rarely seen at Vedanthangal. Their diet consists of aquatic insects, snails, shoots of water weeds and other vegetable matter. They breed in North India during July to August and lay 6-10 grey eggs.

MOOR HEN (*Gallinula chloropus indica*)

The Indian Moor Hen looks like a large black chicken with large feet. The head and neck are blackish grey. The body is slaty grey with a white edge to the wings. The red patch at the base of the beak, and the large green legs with the red patch at the thigh, are also distinguishing marks of this bird. While swimming, it jerks its head forwards and the tail upwards revealing the white circular patch under the tail. Its chief diet is seeds and insects. It breeds about the month of June, when it constructs a nest of weeds and lays 5-12 eggs.

BLACKWINGED STILT (*Himantopus himantopus himantopus*)

These are migrants from the near north. They are about the size of a pigeon, but with long slender red legs giving the appearance of standing on stilts, by which feature alone they can be recognised in the field. The body is mostly white, but the wings are black. The slender straight bill is also black. Their food consists of seeds and water animals, like insects and snails. They breed from April to August, nesting on the ground and laying 3-4 eggs.

SAND-PIPERS (*Tringa hypoleucus hypoleucus*)

The common sand-piper is about the size of a small chick, with an olive green plumage above and white plumage below. The bill is long, straight, slender and greenish brown in colour. The legs are pale-green. The sand-pipers are also winter visitors from the north and come down south after breeding there in May and June. They are marshy birds that prefer the edge of the waterside to a life in water. Their diet consists of insect larvae, snails and worms. They build a nest of grass and during the breeding season lay four eggs in the nest.

LITTLE STINT (*Calidris minutus*)

It is a small bird about the size of a sparrow and is a migrant from Europe and Siberia. It has a grey plumage on the body and the legs are long and slender, but black in colour. It breeds during June and July and lays four eggs in a cup of grass built for a nest.

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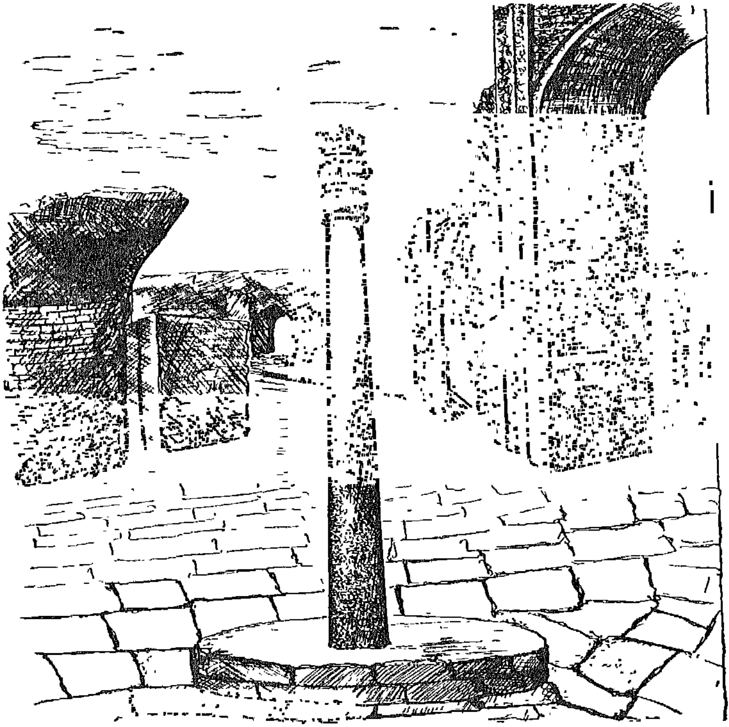
IRON PILLAR OF DELHI

U. S. NIGAMA

Modern School, New Delhi

Whoever visits the Kutab and goes round the campus will come across the famous Iron Pillar in the centre of the huge yard, which once



formed the foreground of a Hindu temple. Along with the many tales, associated with this monument, the guide will invariably draw the visitor's attention to the non-rusting quality of the iron used in constructing the pillar. The pillar has stood there for the last 1,500 years and defied the onslaughts of weather with a will of its own. This resistance to corrosion is attributed by the guides to various plausible causes. They have fabricated many legends around it. It has not failed to attract and arrest the attention of even the most matter-of-fact scientist. Nor has he been a passive onlooker. He has made cuts in the pillar, taken chips out of it and analysed the composition of the metal in great detail, not only to satisfy his curiosity but also to find and learn if possible the secret of its non-corrosive quality. Various theories have been advanced, and although there is a large degree of agreement of opinion on the subject, the interpretation which is acceptable in every part is not yet available.

This iron pillar of Delhi is one of the many specimens of a somewhat similar variety found in different parts of India. Of these the pillar of Dhar, the ancient capital of India, merits our first mention. This pillar is much larger than the one at Delhi. Originally it was forty-three feet and eight inches high, but now it lies broken in three places. It is believed to have been erected as a victory pillar sometime in the 12th century A.D.

Another iron pillar is seen at Mount Abu. This pillar which has a 'trishul' at its top, stands in the courtyard of the Achaleshwar temple, although it was also built as a victory memorial in the fourteenth century. All these pillars are made of the similar kind of wrought iron and have nearly the same composition.

Specimens of iron shafts and beams of the Moghul period are found at a number of places in the country. Iron beams of Konarak temples and Jagannath Puri are also similarly constituted, but while these beams have rusted to a very large extent, the pillar at Delhi has defied the ravages of rain and wind and other natural elements.

The iron pillar of Delhi is one of the oldest. It is believed to have been made in the 4th century A.D., and bears an inscription in Sanskrit in the Gupta script. Some hold that the pillar was originally in Mathura on Mount Vishnupada, others believe it was in Mehrauli on a hillock called Vishnupada, but all are agreed that it was moved to its present location about 1050 A.D., when Anangpal rebuilt the city of Delhi.

The pillar is twenty-three feet and eight inches high, of which 22 feet are above the ground. Its diameter is 12½" at the top and widens towards the base to 16½". Its specific gravity is 7.81 and its weight is estimated at about 6 tons. The pillar stands erect, its base resting on iron bars fixed to the stone pavement with lead.

There are two very striking features about the pillar—its size and its non-vulnerability to the formation of rust. It speaks highly of the

Indian metallurgical skill—that as early as over fifteen hundred years ago, they could forge such a huge and shapely pillar, a feat which was almost impossible for any foundry in England or Europe till about a hundred years ago.

Its non-corrosive quality has aroused the curiosity of many scientists and some have taken up the investigation of the problem. J. C. Chaudhuri quoted its chemical composition as follows :

	0.080	C
	0.046	Si
	.006	S
	.114	P
	0 032	N
	99.72	Fe
	Nil	Mn
Total	99.998[1]	

A number of reasons have been attributed to the non-corrosive quality of this iron. Some suggested that it was due to the smearing of butter over it. Even if this was a practice in earlier times (which is doubtful), how long would its effects last and to what height could this anointing be done in practice ? Also, places from which the protecting layer is removed, would be exposed to corrosion. The pillar has many cuts and scratches made on it from time to time, and yet it has not rusted at those places.

Others think that the iron used in the construction of this pillar is 'barffed' iron. Barffing is the process of heating iron with super-heated steam so that a protective 'casting-skin' is formed over its surface. The signs of such a skin are not easily detectable and need further investigation.

Rosenhain's theory of protective layers of fused slag being formed as cinders over the surface of wrought iron when it is *heated*, does not also commend itself, for again, places where cuts had been made, should have rusted by now.

Hudson[2] studied this problem from another angle. He studied the weather conditions of Delhi. He was particularly struck by the dryness of the Delhi atmosphere. W. H. J. Vernon has shown that the relative humidity should be at least 70% to cause the rusting of iron. But through the major part of the year, the humidity in Delhi remains much below 70%. In Hudson's opinion the non-rusting quality of the iron in Delhi pillar is mainly due to the mild corrosive nature of the city's atmosphere. P. C. Ray writes "Hudson has shown that the relative humidity of the air at Delhi seldom exceeds 70 per cent which according to the classical researches of W. H. J. Vernon serves as the critical limit for the atmospheric corrosion of iron and steel to set in. This should therefore lay to rest all speculations and eliminate all hypotheses, regarding the alleged intrinsic superiority of the iron of Delhi pillar, so far as its corrosion resistance is concerned". The statement is obviously overemphasized. It is well known that once a layer of rust is formed, it protects the inner material from further damage.

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[1] Chaudhuri, J. C. JOSWA Vol. 5, No. 1, 1957.

[2] Hudson, J. C. *Nature*, **172**, pp. 499-500, 1953.

Whether it is a protecting layer or the purity of iron, especially the well nigh absence of copper and sulphur, or if it is the mild Delhi weather, or if it is a combined effect of all these, has still to be placed on a decisive footing. In Hudson's opinion all the three factors should provide the answer to this query. In fact the answer is still far from conclusive. Sir Robert Hadfield's recent investigations and the suggestion by Chaudhuri deserve closer study in any future work on the problem.

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LANGUAGE, COMMUNICATION AND TEACHING METHOD

FRANCIS SHOEMAKER

Professor of English, Teachers College, Columbia University, U.S A.[*]

Man communicates through two symbol systems. Both are his most complex inventions (starting with *zero* and the alphabet, and moving perhaps to E = Mc and the works of Prem Chand), which he has made in gradually extending his control over his environment. One is the many-faceted symbol system of number and notation by which he measures and records duplicable and verifiable information and data and predicts phenomena in the realms of physics, chemistry and biology. The other is the also many-faceted symbol system of the arts, in which he expresses individually perceived and individually felt values and responses to the meaning of life (including the data of sciences) This second system includes the individually phrased linguistic symbols (in literature), the perceived symbols of colour and line (in painting), of shape and texture (in sculpture and architecture), of tone and intensity and quality of sound (in music), and of body movement (in dance).

The scientist and teacher of science are both fully conscious of the discursive symbols which are the centre of their professional life. And some, though not all, are aware of the significance of the other humanizing symbol systems, without having had to turn definitive attention to them. At the same time, their professional and non-professional lives depend completely on the quality of their use. The purpose of this discussion, then, is to sketch briefly some of the major aspects of the language of words, its relation to human development, to social change, and to the evaluation of science itself—moving finally to some significant questions which teachers of science must face and answer in non-scientific terms if they are to teach well.

Language is unique as a medium for communication. It is not only the medium through which we learn ; it is also the medium through which we learn about the medium (language) through which we learn Is this too complicated ? We use language to study language ; when we do this we are beginning the most profound aspect of self-study. Many of us, I imagine, feel that man possesses the medium of language through which he controls his environments. I don't believe this at all. I believe that *man is his language*. Without language he is an animal. With thumbs with which he can grasp things, he is still incapable of spirituality without language. Language makes it possible for him to imagine things that are not present in space, things that are distant in time and things that are non-corporeal and non-human, that are ethereal and which relate him to his conceptions of deity. This puts language at the very centre of all of our human endeavours in philosophy and religion, and art and science and education and politics. Language makes us human.

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[*] Dr. Shoemaker is at present a member of the Teachers College, Columbia University Team of Consultants working with the National Institute of Education, New Delhi.

We are familiar with the term *Homo sapiens* man thinking, man with wisdom, man with intelligence. But underlying this quality is a perhaps more appropriate one, *Homo signifex*. Man using symbols becomes man with intelligence; man with intelligence becomes man with values; man with values becomes man with potentialities for love, because he can identify himself with the lives of other people. Language is therefore the central nervous system of human society.

HISTORY OF COMMUNICATION

In the time of Harappa and Mohenjodaro, even in the times of the actual enactment of the *Ramayana* and *Mahabharatha*, there was only oral communication of people who had experimented with sounds sufficiently to agree that the same sound indicated or referred to the same thing or event. As society developed, leadership emerged. The law was the order of the leader, and the continuity of law lay in what one man could remember. (This is still true to some extent in the village and of the headman today, isn't it ?)

Then came a momentous revolution, the first of four in human communication. Man invented the alphabet. With the alphabet he began to inscribe letters or figures on clay and on wrought iron and on marble, as Ashoka did. He became able to make permanent and available to other people the things that previously only the emperor had known. In this way the Ashoka pillars, for instance, provided for dissemination of the law of one man. This constituted a revolution in human society. The invention of the alphabet may have been more dramatic and far-reaching for the history of man than the invention of Friendship Seven, because it gave to individual man the right to begin to understand for himself what his own environment held for him.

The second revolution came to India- and to the Middle East—at approximately the time of Chandragupta Maurya. It followed on the invention of new material to replace granite and wrought iron on which to write. When a ruler could write on a piece of parchment or a piece of papyrus, and roll up the manuscript and put it into the hands of a messenger, as Chandragupta did, sending his emissaries east and west and south to establish his Empire, he was able to bring many men together into a larger, integrated society. Similarly, the Roman Empire became possible when Caesar was able to write his laws on a manuscript and send them to the British Isles, to France, to the forests of Germany, and even to the delta of the Nile. He was able to rule a tremendous empire, and begin the accumulation of cultural values because of a mere invention of a light material that could be carried, while it carried a message.

The invention of portable writing material, however, did not give everybody the chance to share in the information and direction of the world ; the third great communication revolution came in the fifteenth century about 1470 when Gutenberg, a German carpenter said : 'I think I could make wooden letters that would look like letters which people write with the stylus, and I could stamp them on parchment and then I could stamp again and again and have thousands of copies which would otherwise take thousands of years for people to produce by hand'.

Gutenberg's press brought the third great revolution. The new knowledge that man had about the world—the sailing of Columbus, and of Vasco da Gama, and Magellan—all this information was printed and disseminated over the European world. At the same time, new information about past cultures of Greece, Rome, Egypt, and India was similarly printed and spread. The printing press also multiplied new information about economics and agriculture ; and the new world commerce grew on printed forms for double-entry accounting systems. The printing press really changed the visible aspects of the whole of human society.

Perhaps the most far-reaching result of the third communication revolution was an invisible one, which only twentieth-century scholarship has come to understand. The printed book made it possible for thousands of people to get information for themselves. Any individual could take a book, by himself, into the privacy of his own room and read and re-read what earlier he had only been able to listen to as some one read to him. The printed page became a kind of intellectual mirror, in which a person could see the symbols of his own ideas. He could look at the page and say, 'Aha, that is the idea I have here in my own head'. He became able to know his idea as his possession ; he became aware of himself as a person. He became aware of his self. It is significant that Shakespeare, writing approximately a hundred years later, provides the first significant use of the term 'self' in Renaissance literature. He makes Polonius say to his son : 'First to thine own self be true ..' There is nothing else to which the emergence of self-awareness can be so closely attributed as to the invention of print. This third revolution in communication is the base for modern man's conception of himself as participant in the processes of his own evolution.

The world is now in the early stages of the fourth revolution in communication. It began with the first electric transmission of sound in the Marconi telegraph at about the opening of this century. It continues with innumerable electronic devices for recording, duplicating, magnifying and transmitting pictures and sound. This revolution, as we noted, is in its early stages of development. But we are well on our way to making the *total accumulated and accumulating culture* of mankind instantaneously available to anyone, anywhere in the world.

India provides illustration for each stage in the evolution of communication. Harappa and Mohenjodaro provide no evidences of writing. The Ashoka pillars and inscriptions attest to the extension of normal and legal codes through writing. The documents of Chandragupta and later rulers provide ample evidence of the emergence and significance of portable writing materials.

Current estimates show approximately 21 per cent of the population literate, i.e., able to read and write sufficiently well to carry on normal activities of business and responsibilities of citizenship. And at the same time, the A.I R. and the prolific motion picture studios of Bombay, Madras, and Calcutta (not to mention studios of other cities of the world) provide the populace with electronically recorded and transmitted images of many kinds.

Western culture has lived in the 'print revolution' for nearly 500 years. Eastern and African cultures now recognize that literacy is the avenue through which they can achieve self-understanding and self-direction. Teaching for adult literacy is one of the primary interests of the National Fundamental Education Centre in Delhi. If literacy comes rapidly to India, the anticipations of millions of people will be heightened—and partially realized. But this will bring an explosive revolution in every aspect of Indian life. In education it will become impossible to continue the traditional patterns of schooling which even now we know are inappropriate for modern living. At the same time, as millions are idealizing literacy in print, similar millions may skip right over this revolutionary phase and land squarely in the middle of the audio-visual world of movies and television. Will they do this without having matured in self-understanding and self-direction? And if so, will education show the way to using these newer electronic media to help mature the human self? If, or when, this stage is reached, the fourth electronic revolution may have reached its zenith—and our global civilization will be ready for its yet unidentified fifth revolution in communication.

IMPACT ON EDUCATION

Perhaps we should expand somewhat on the implications for education of this newest communication revolution. There are two we should look at now. First, the electronic revolution has extended the range and accuity of the sensory organs of the human body. Up to recent times all education came to us through our own senses—ears and eyes, for instance, and our speech and writing which we listened to and read as our own first audience, to know what we thought. Where once our vision was limited to 12 miles to the horizon, we can now see around the world with such transmission miracles as Telstar. Where once we could hear speech only within reasonable conversational distance, we can now turn antennae in any direction and hear voices from any part of the globe. Where once we could project our voice a few hundred feet, we can now whisper and be heard around the world. So the electronic revolution has given our bodies a global reach never before experienced.

Second, the electronic revolution makes available so much new information that we can scarcely handle it But our young people are learning to take it in stride. School age children in the United States average six hours a day in school, four hours a day with television (which means approximately 20 programmes from many parts of the world) an unmeasured amount of time with two newspapers that come to their houses each day, and similarly unmeasured hours with the several weekly and monthly magazines that they read. The immediate result of this exposure to vast quantities of information is that they enter school at age six with a vocabulary of over 14,000 words. This is not because they are brighter than their parents (we may have averaged 6,000 words twenty-five years ago), or that they are brighter than children elsewhere. *It is simply that their communication environment is immeasurably richer, and they have greater opportunity to approximate their potentialities than other youngsters who do not have this intellectual-emotional feast always spread before them.* It is an interesting note, in passing, that an integral part of the definition of Ambassador Galbraith's 'affluent society' is the abundance of information and new knowledge available to everyone.

I have used the United States as primary example of the farthest reaches to date of the electronic revolution ; but I also think that comparable developments will reach India virtually 'day-after-tomorrow'.

A third aspect of the communication revolution which has bearing on education is the direct outgrowth of the increase in available information. Where we once thought the classroom was the major channel for the flow of information and the transmission of facts and values in the culture, we now know that this is no longer true. We know that children have access to more and learn more every day through other channels of communication than the classroom. What does this mean for formal education—and for teachers in the classroom ?

ROLE OF THE TEACHER

The functions of the school and the teacher change. We do not continue with former routine procedures, perhaps trying to do them better to compete with the electronic media. And we don't condemn the media as intruders on the time and attention of children. But we do examine the nature of the unrelated and otherwise chaotic material being presented. We observe the need for design. The teacher's function then becomes one not only of imparting information, but of *teaching the ways to organize information, and the ways to evaluate it, and the ways to think about it.* This is teaching of values and teaching of methods of organization. A disorganized life is not a very interesting one. The teacher must help people to organize their lives, to achieve a 'design for living'. Their lives may be organized at the level of sheer physical subsistance. They may be organized at the level of narrow attention to creating and fostering a family. Or they can be organized at the level of creative innovation and contribution of an original nature to the society. These alternatives put greater responsibility on teachers than we have ever shouldered before. It puts us into what is probably the most strategic position in society.

So the communication revolution has totally altered the situation in education. This change seems not to have come to every village school yet. But it may have come more fully than we let ourselves realize. We may still be looking in the textbook for the daily lessons, and not into what the youngsters have heard over the radio the night before. If we deny to them the chance to think constructively about what they have heard over the radio or seen at the movies, we are not making the school a participating part of the community. *The school ought to help them to do better what they are going to do anyway.* It should not try to make them do something which is extraneous and foreign to their normal lives.

What has this to do with 'teaching method ?' Let me try to point up some relevancies now. In the first place, the dramatic impact of communication on culture generally has led to study of communication processes by social scientists in a number of countries, including India. One political scientist at Yale University, Harold Lasswell, proposed a kind of 'formula' for examining any communication situation. It is simply 6 questions.

Who ?
Says what ?
To whom ?
Under what circumstances ?
Through what medium ?
With what effect ?

Educators, observing that *any classroom is a communication situation*, use this 'formula' to determine just what happens in a class. Now let's suppose that you apply this formula to your first class tomorrow morning. How many marks will you give yourself in your class as you answer these questions ? Let's take each one in turn, phrasing the questions personally for each teacher.

WHO ? 'Who talks in my class ? I do, of course. But *who am I* ? I come from a family which has been far more favourably circumstanced than that of any of my students ; so the values I try to transmit are not their values or their parents' values. How do I reach them, to translate and transmit full understanding of India's diversity ? Am I capable of this task without passing on my personal biases ?'

In addition to this fundamental introduction generated by the interrogative 'who ?', there is the question of the observable speakers in the class. 'Do I do most of the talking ? Do my students have opportunity to speak in class ? Do I ever bring into class men and women who know first-hand the problems being studied in class—people from government, from industry, or doctors, scientists, authors, community development workers ?' Such a series of analytical questions, you see, could challenge the teacher to alter the actual method of managing the class. But let us reserve further comment on this until we examine the class-communication situation from the other key points of reference.

SAYS WHAT ? 'Whoever speaks in my class, does he merely repeat the words of the textbook ? How much of the vast world of new knowledge finds its way into the classroom ? When they recite, do I function as a judge and say 'Right. Sit down !' or 'Wrong. Sit down !'—or do I pose the kinds of questions for discussion that can only be responded to by some original, hard thinking, which cannot be 'right' or 'wrong' but always an approximation to fuller and fuller information or skill in thinking ?'

TO WHOM ? 'Who are my students ? How much do I know about each one, personally, his abilities, his interests, his aspirations, his affections and his heroes, whose lives he uses as models for his own behaviour ? In my classroom, does my attitude make him a different person from his normal wont—perhaps reluctant or rebellious ? Or do I enlist his maximum efforts, his enthusiasms, his devotions that constitute his best self ? When I ask a question, do I direct it to a single pupil—so that only he feels responsible for answering it ? And does he give the answer just to me ?—or do I pose questions that involve the interests of the whole class, so that any pupil's response can in turn be the subject of comment by other pupils ?'

UNDER WHAT CIRCUMSTANCES ? The classroom, of course, is a unique circumstance. Childern of approximately the same age are crowded into a single room with inadequate light, air or moving space.

Their normal world of manipulation of things—tools, animals, stones, food—is from one point of view diminished to the manipulation of words; from another, it is infinitely expanded to embrace the world's content, if the words symbolise things and concepts sufficiently familiar to have meaning. The 'artificiality' extends to the uses of information transmitted in the classroom. The teacher may well ask such a series of questions, then, as these: 'What sacrifices have my pupils' parents made to put them in school? Have they come willingly and in high expectation of learning? Have I selected material for study that is pertinent to the lives of the students? How much of their attention is focussed on passing the examination, and how much of it on getting information and skills that have value far beyond the examination? As each day ends, can I honestly say that what I have done will contribute to some constructive change for my pupils?'

THROUGH WHAT MEDIUM? When social scientists applied this question to communication situation in community life their answers usually indicated either books, radio, motion pictures, television, newspapers, magazines, or billboards. The adaptation to the classroom doesn't alter the potential responses very much, though in actuality, with power and electronic equipment at a minimum, motion pictures and television at this moment will not be widely used. Nevertheless, the teacher inquiring into his own procedures may well ask himself: 'Do I depend solely on print for instruction, and within that medium, almost entirely on books? Or do I see to it that newspapers become a source of information and *a basis for instruction in how to read* to keep a balanced and informed view of the world scene? Do I use the content of the All India Radio for new information and a basis for instruction in how to listen, to keep up with the current scene? Do I use pictures, whether motion pictures or still pictures, to provide *referents* for new vocabulary and *a basis for instruction in how to observe,* to enrich the world many of us walk through virtually blind to colour, shape, texture, and design. Do I use student compositions to share information in the class and as *a basis for instruction in how to write,* to clarify one's own ideas for himself and others? Do I keep the students in their seats, or do I provide opportunity for sharpening ideas in discussions, round tables, demonstrations, and as *a basis for instruction in how to speak* in varied situations, to varied audiences, for varied purposes?'

WITH WHAT EFFECT? The purposes of communication vary broadly. When we talk *to* or *at* people, as Hitler did, the process is essentially 'one-way'—from the speaker to the hearer, with expectation of total agreement, conformity and obedience. When we talk *with* friends or respected associates and pupils, the process is essentially 'two-way'—with expectation of the hearer's responding thoughtfully to what we say, trying to understand so that he may appreciate our point of view, without necessarily adopting it. When we talk *with* people, face to face, we watch their expressions to see whether we have 'communicated' successfully and whether they approve, negate, question or qualify. Their expression is a form of response ; it is 'feed-back' which tells us how to modify our next statement to effect a meeting of minds with our listener.

The situation in the classroom is basically the same. The teacher, presumably, is constantly concerned with the success of his communicating —and the success of his management of the communication of others in the room, as in his system of questioning, his invitations to special people to supply otherwise unavailable material to his students. As he checks himself on the efficiency of his communication, he may well be thoughtful along such lines as these : 'What results do I want from my teaching ? What is the best method for informing myself of the extent of my success ? Is a terminal examination the best way ? Or does it come too late to diagnose my pupil's problems in understanding me or the material, and hence too late to re-teach or re-direct thinking along rewarding lines ?'

As we think back over the six leading questions—Who ?, Says what ?, To whom ?, Under what circumstances ?, In what medium ?, With what effect ?—we realize that all of our subordinate questions deal with methods of conducting a class. This aspect of classroom management is teaching method as we have conventionally thought of it.

EFFECT ON TEACHING METHOD

Our new awareness of communication processes, though, suggests that there is an additional dimension to teaching method that we will be paying more and more attention to in the next few years, starting now. This is the way we vary our *teaching method* to relate it to the *methods of study and research* of the scholars in the academic fields we teach. How, for instance, do our methods of teaching science relate to the methods of inquiry of the professional scientist ? Do they challenge the student's *curiosity* to uncover problems, his *imagination* to experiment with their solution, his *will* to persevere in his work, his *thrill* and *excitement* in achieving by himself some acceptable solution ? It seems imperative that we devise classroom procedures for handling the various subject matters, so that the pupils, who are our next generation of scholarly leaders, will *know* what it is like to work in any given field, and be able to choose a profession for themselves which will enlist their unstinted energies and professional attitude and loyalties.

Briefly, how might this proposal guide our handling of classes in the several subject fields ? The research scientist always works on still unsolved problems, [illegible] solving old ones. Can the science teachers devise single, unsolved problems in which the student's learning how he goes about the solution is much more important than the solution itself? The social scientist works constantly with problem situations which have no single cause and no single result. He knows that every problem has multiple causes and every solution multiple effects. His goal is to achieve maximum constructive effects. Can the teacher of social studies, history, human geography set up learning situations which teach the patience and discipline of the professional? The scientific linguist studies languages as they are spoken and written in daily life, not in books about language. Isn't this also the basic language laboratory for students of language? What procedures can the language teacher use to help students observe the structure of language and the consequences of the use of varied constructions? The practising artist, whether painter, author, composer, architect or dancer is primarily concerned with giving form to otherwise chaotic aspects of life. He is 'on his own' in this difficult process, not copying other art works, not asking a friend how to put in the next line or word or note or movement. What does the teacher in each of these art mediums do to afford both the discipline and the freedom (and the freedom that comes through discipline) to solve the problems of form?

Each teacher as a professional educator has the responsibility to lead his student to understand the values and acquire the attitudes and skills of the professional worker in other fields of endeavour. His function is to help young people re-examine the processes of testing hypotheses and of creating new knowledge. This is only possible through language. It is one of the most important forms of communication, and like all other processes, can be improved if we raise it to the level of consciousness and work on it.

CLASSROOM EXPERIMENTS

HOW TO MAKE A SLIDE RULE

Slide rules are being used extensively in business and industry and it is therefore necessary to begin at the school level to give the students some idea of its construction and use. It can be easily constructed (at least for rough calculations) in the school workshop by the students themselves. It is an activity, tapping the creative instinct of the students, to useful purpose.

Articles Required :

A stiff piece of cardboard, a ruler, a hard pencil, a sharp cutting knife, and an eraser

Procedure :

1. First cut three rectangular pieces of cardboard of the following measurements .
   base piece 12 inches by 2 inches,
   two upper ones, each 1 inch by 12 inches.

2. Place one of the 1″ strips on top of the 2″ strip, so that the upper half of the base strip is completely covered by the 1″ strip. These two strips will form a rigid part of the slide rule on which the other remaining strip of 1″ width will have to slide on the lower side of the 1″ strip fixed to the base strip.

3. Place the other 1″ strip on the base strip in contact with the fixed 1″ strip and on the lower side of it. Take care to keep it fixed in that position until you finish marking the slide rule.

4. For convenience of reference let us call the upper strip Y and the lower strip X
   Now mark a distance half an inch from the left side of the base and draw a vertical line—very thin—to mark this starting line on both X and Y.

5. Mark this starting line as '1' and call its left hand end '1'. From this left hand '1' line measure exactly 6¼ inches distance towards the right hand end, and draw a vertical line perpendicular to

the line between X and Y. Mark this line also as '1' and call it Right hand '1' mark

6 You must be extremely accurate in making the marks described above. Your accuracy in making the slide rule depends upon your skill in making these marks and drawing the vertical lines very thin and correctly placed at a distance of $6\frac{1}{4}$ inches apart.

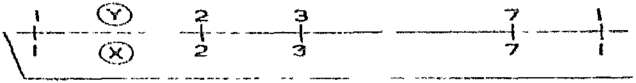
7 Now measure off exactly $1\frac{7}{8}$ inches from the L. H. '1' mark and make another thin vertical line at this point on both X and Y. Call this mark 2 on both the scales.

8. Then measure off $2\frac{31}{32}$ inches from the L. H. '1' mark and again draw a vertical thin line and mark it '3'.

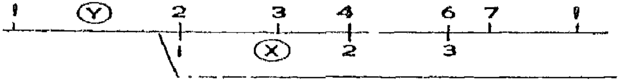
9. Similarly make another thin vertical line at a distance of $5\frac{9}{32}$ inches from L. H. '1' mark and call it '7'

10. Now you have the markings 1, 2, 3, 7, and the 1 on the right hand side. If you have all the markings correctly made, your slide rule will give you accurate results, if not, there will be errors in your calculations later when you use it.

11. You have the slide rule now as shown below :



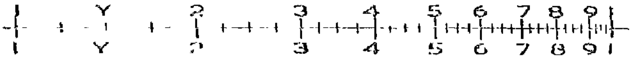
Now slide the X strip along towards right so that the L. H. '1' mark coincides with the mark '2' on Y strip. Then produce the line '2' on X upwards on Y and mark it '4' ; also do the same thing with mark '3' on X and the line produced upward on Y may now be marked '6'. Repeat the procedure for '7' marking the line on Y as '14'. The slide rule will look like this :



12. The Y scale has now markings 1, 2, 3, 4 and 6, 7 and the R. H. '1'. If you place the '1' of X directly below the '4' of Y,

you will get '8' mark on the upper scale, directly above '2' of the X scale Again by putting '1' on X scale below '3' on Y you will get, '9' mark on the Y scale directly above '3' of X scale.
Thus, you have all the marks from 1 to 9 on the upper scale except '5'. To get this '5' mark on the upper scale, place the '2' of the X scale below the R. H. '1' of the Y scale and mark off the line on Y obtained by producing the '1' mark line on X upward as '5'. Thus you have all the markings from 1 to 9 on the Y scale and the R. H. '1' of that scale serves as '10' mark.

13. Now bring back the lower scale, make the L. H. '1' on both the scales coincide, and mark off all the remaining figures on the lower scale exactly as on the upper scale, producing the respective thin lines from the upper scale to lower scale. The scales should now be absolutely identical in appearance as shown here.



14. At exactly $\frac{1}{4}$ inch from the L. H. '1' on both scales mark off, 11 (or 1·1), and at exactly at $\frac{11}{16}$ inch from L. H. '1' mark off 13 (or 1·3) and proceed to mark other details given below.

15. Before proceeding further, it is important to note that the unit digits 1, 2, 3, 4, 5, 6, 7, 8, 9 also represent 10, 20, 30, 40, 50, 60, 70, 80, 90 or 100, 200, 300, 400, 500, 600, 700, 800, 900 etc., respectively.

16. In the same way, 15, 25, 35, etc., represent also, 1·5, 2·5, 3·5 or 150, 250, 350, etc., respectively

17. Now to obtain other markings, place 2 of X under 3 of Y and mark off 1·5 or 15 above the L. H. '1' of the X scale. Also mark off 4·5 or 45 on Y scale directly above 3 of X.

18. Place the 2 of X under the 5 of Y and mark off 3·5 or 25 above the L. H. '1' of X.

19. Place the 2 of X under the 7 of Y and mark off 3·5 or 35 above the L. H. '1' of X.

20. Place the 2 of X under the 9 of Y and mark off 4·5 or 45 above the left hand '1' of X.

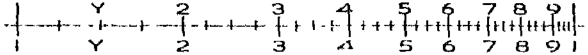
21. Divide the spaces between 8 and 9 and R. H. '1' in half and mark off 8·5 and 9·5

22. Place now the L. H. '1' of X under the 11 on Y and mark off 5·5 or 55 on Y above the 5 on X. Do the same for the 13 on Y, and mark off 6·5 or 65 on Y.

23. Place the L. H. '1' on X under 15 on Y and mark off 7·5 or 75 on Y directly above the 5 of X.

24. Now place the 5 of X under the 6 of Y (this is like placing 10 of X under the 12 of Y) and mark off 1·2 or 12 on Y above the left hand '1' on X. Do the same for 7 on Y and mark off 1·4 or 14 on Y above the L. H. '1' of X.

25. Your upper scale has now 11, 12, 13, 14, 15, marked off in it as well as 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, and the right hand '1' as shown in diagram here.



26. The rest is now easy. Place the L. H. '1' successively under 11, 12, 13, etc., and use the 2 on the X scale to mark off 22, 24, 26 and 28 between the 2 and 3 on Y scale.
To get 16, 17, 18, 19 on Y scale place the 5 on X under the 95, 90, 85 and 80 of Y respectively and mark off 19, 18, 17 and 16 above the L. H. '1' on X.

You can proceed in this manner to complete the other details. The two scales obtained must however be identical.

Your slide rule is now ready for use.

G. K. Athlaye

THE 'MERCURY HEART'*

This is a simple experiment which will give plenty of fun and at the same time provide definite material for thought.

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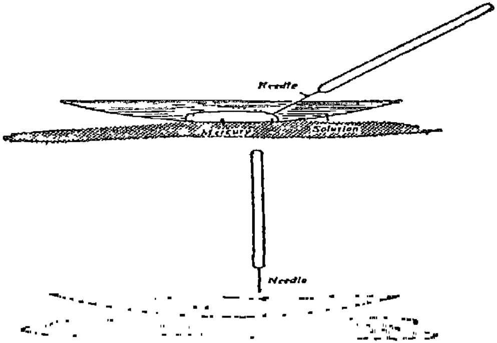
* Taken from the '*Science Masters' Book* Part II, Series II, John Murray, London.

Pour a drop of mercury, about ⅜ in. diameter, into a clock-glass, cover with water, add a few drops of sulphuric acid and stir in a crystal of permanganate, or a few grains of powdered potassium dichromate.

Fix a sewing-needle, mounted in a wooden holder, in a retort stand, and bring this up until the point touches the mercury in the positions shown in figure. When once started, the drops will continue to 'beat' for a good time. The starting requires some patience ; a change of needle may help, for no apparent reason. The needle must be steadied.



A Suggested Explanation : The effect appears to be due to the formation and polarization of a simple mercury-iron cell. When the needle touches the mercury, a current passes and a minute layer of gas (H) is evolved at the mercury. Now the drop assumes such a shape that the sum of the gravitational and surface energies is a minimum. But the surface tension of a mercury-gas interface (466) is greater than for mercury-acid (320). Thus, when gas is formed, the surface energy becomes greater ; hence the drop becomes more spherical, thus retreating from the needle. Upon disappearance of the gas (greatly hastened by the depolarizing action of potassium permanganate), the surface tension falls again, the drop widens once more, touches the needle and the whole action repeated. This is confirmed by touching the drop with one end of a platinum wire, when no effect is produced ; but if the other end of the wire is twisted round a needle, the phenomenon is observed whenever the needle is dipped into the acid.

Without potassium permanganate there was no oscillation, but only a single quiver of the drop as the needle touched it. The magnitude of this quiver fell off with repeated contacts, and after four or five, it could not be detected ; the cell evidently polarized rapidly. This effect was so small that one would fail to detect it until he had seen the phenomenon with potassium permanganate present.

'PHARAOH'S SERPENTS'*

The author recently discovered accidentally that excellent 'serpents' can be made by the following method.

p-Nitroacetanilide (5 to 20g.) is added to $\frac{5}{9}$ of its weight of concentrated sulphuric acid (1 mol.) in a small porcelain dish and the mixture is heated strongly on gauze, when it melts and a vigorous reaction begins to set in at about 200°c. This is rapidly followed by a mild explosion, in which a large snake-like mass of carbon shoots out. In this way 'snakes' a yard in length and as much as 5 in. in diameter can easily be obtained from a 100 cc dish. The snakes are black and sponge-like, and they are not nearly so brittle as those obtained from mercury thiocyanate.

Where a fume cupboard is available, it has been found that the experiment is admirably suited for lecture demonstrations. Acetic acid vapour is the main gaseous product evolved.

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* Taken from the *Science Masters' Book* Part II, Series II, John Murray, London.

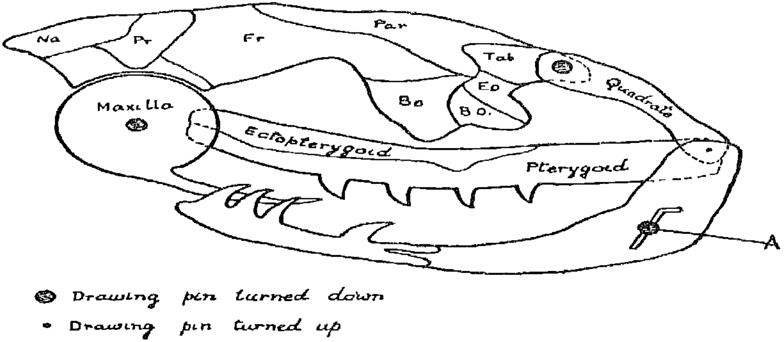
STUDY OF THE BITING MECHANISM OF A SNAKE

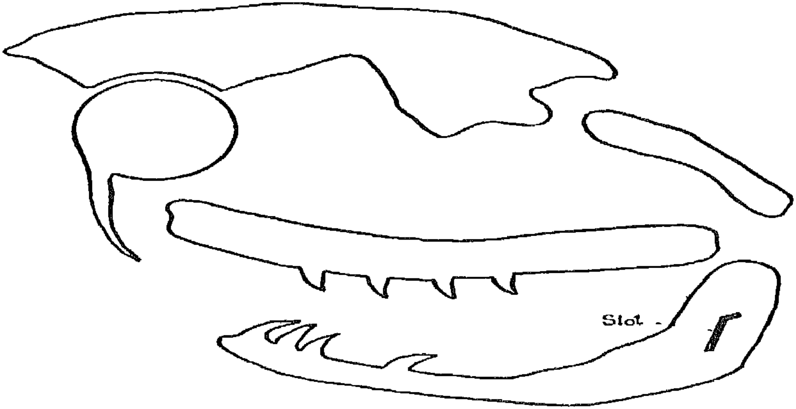
The students usually express surprise when they are told that an ordinary snake can swallow another animal much greater in size than its own mouth. Also it is pretty hard to understand the action of the movable quadrate bone with the help of either a mounted skeleton of snake's skull or from a diagram. In a mounted skeleton the quadrate is immovably attached to the skull and the lower jaw.

The fact that the poison fangs are made to open outwards as the mouth opens, is hard to understand for the young learner.

Both these phenomena can be explained by means of a working model which can be very easily made by the students themselves in the class. The idea of the model is not original and has been taken from the Science Masters' Book Part II, Series II. It cannot also be claimed that its construction has full accuracy. However, it illustrates the principle of the mechanism whereby the gap of the mouth is made unusually large, and at the same time, the poison fang is made to move outwards as the mouth opens.

The accompanying diagram is made to scale and needs only to be cut out. Plywood would be certainly better than cardboard. Nothing of





the nature of the pins exists in the actual skeleton and the pins are merely meant to keep the parts in position. The parts as drawn may be fixed to a base board after they have been cut out.

The chief difficulty in getting the model to work is finding the position of the pin A. A suitable position for this pin is suggested on the diagram. By varying the position of the pin, a gap of various sizes may be obtained. This pin of course, is an artificiality, and does not exist in the animal. It is, however, necessary for the working of the model and may be concealed by a piece of paper.

All that will be required to be done is to push downwards at the point of articulation of the quadrate under the lower jaw

PLAN OF A TEACHING UNIT-2

N. K. SANYAL

Deptt. of Science Education, N.I.E., Delhi

This is the second of the series of a plan of teaching unit based on the Unit Approach to Teaching Science as discussed in the previous issue. The topic is suitable for class VII and discusses transmission of heat.

Topic : How heat travels and affects our lives.

I. INTRODUCTION

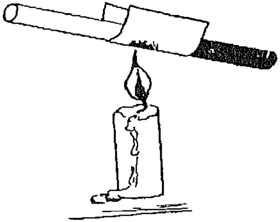
A. Experiments :

(i) Take a metal rod and a wooden rod of the same length and thickness. Keep one end of each in the fire of a stove or '*angithee*' for some time, holding the other ends with your hands. After a short while which one is warmer at the other end ?

(ii) Keep a copper coin on a piece of paper and carefully warm the piece of paper below the coin. Which part of the paper is singed first ?

(iii) Keep some crushed ice in a thermos flask, cork it and keep it aside. Keep an equal amount of ice in another open ordinary vessel. Examine after some time the difference in the quantity of ice left in each vessel. Why is this difference ?

(iv) Take a hollow brass rod in which is fitted a wooden rod of the same diameter. Wrap a piece of paper at the juncture as shown in the figure and warm it over a spirit lamp flame for a few moments. Which part of the paper singes first and why ?



B Discuss the preliminary experiences and possible causes of some of the experiences like the following to ensure motivation of the pupils :

(a) Why do we keep ice covered with saw dust and wrapped in gunny ?
(b) How is it that the whole of a metal rod gets heated when one end is put in fire but a wooden pencil does not behave so ?
(c) Why does the metal knob or handle of a door feel colder than the wooden panel on a winter morning ?
(d) Why does tea remain hot in a thermos flask for long hours and yet ice can be kept without melting for many hours ?
(e) Why do we use a quilt to protect us from cold in winter ?
(f) Why is there a chimney for a fire-place or furnace ?

II. QUESTIONS AND ANSWERS

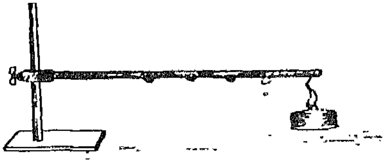
The problems and questions which remain to be answered are :—

1. How does heat travel in solids ?
2. Does heat travel in all solids at the same rate ?
3. How does heat travel in liquids ?
4. How does air get heated ?
5. How does the heat from the sun reach the earth ?
6. What is radiation ?
7. How are winds formed ?
8. How does the thermos flask work ?

III. ACTIVITIES AND EXPERIMENTS TO BE USED IN SOLVING PROBLEMS AND ANSWERING QUESTIONS

1. *Heat travels through solids by conduction.*

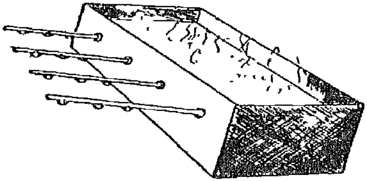
(i) Fix a few beads by wax to a metal rod and fix it horizontally to a clamp, as shown in the figure. Warm the free end of the rod by a spirit lamp. Observe what happens to the beads on the rod. This process of transmission is called conduction. Conduction requires a medium.



(ii) Light a thin candle and touch its tip with a copper spiral (made by winding a copper thread around a pencil) and see what happens. Then first warm the tip of the copper wire and repeat the experiment. Do you find any difference ?

2. *Does heat travel in all solids at the same rate ?*

Take a metal box containing 4 or 5 holes on one side. Take an equal number of different rods (copper, iron, brass, zinc, wood, aluminium, etc.) of the same length and diameter. Fix the rods tightly into the corks and fix one rod in each hole.



Fix a few beads on each rod as in the previous experiment. See that the same length of each rod is inside the box.

Put boiling water in the box. See what happens with rods in each case. If a watch is available, record the results as follows :—

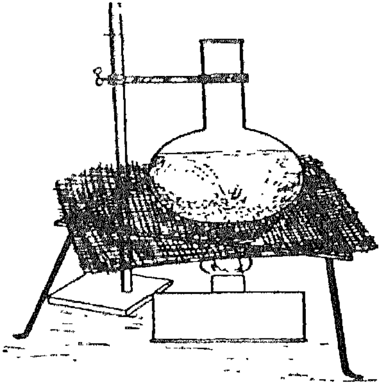
Material of Rod.	*Falling of beads. Time in seconds.*				
	1st	*2nd*	*3rd*	*4th*	*5th*
Iron Copper Wood Zinc Aluminium Brass					

3. *How does heat travel in liquids ?*

(i) Fix a test tube half full of water to a clamp in an inclined position. Wrap a piece of ice in a small piece of wire gauze and put it at the bottom. Warm the top of the water level till steam starts coming out of the mouth of the test tube. Touch the bottom of the test tube. Does it feel hot ? Does appreciable amount of ice melt ? What does it show regarding the conductivity of water ?

(ii) Repeat the same experiment (without ice) using mercury in place of water. Observe the difference by touching the bottom of the test tube.

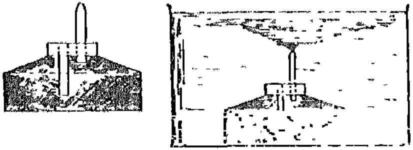
(iii) Fill a flask or a wide beaker half with water. Put it on a wire gauze over a stand. Carefully drop a crystal of potassium permanganate



and warm the water. See the movement of coloured water in the vessel.

Let the pupils deduce that the heat from the bottom is carried by water molecules upwards and their place is taken by others from the top. This process is called convection and the circulation of the liquid is called convection current.

(iv) Fit an ink bottle with a cork carrying two pieces of glass tubing as shown in the figure. One piece should be drawn as a jet and extend about five centimeters above the cork. The other tube should be level with the cork and extend nearly to the bottom of the bottle.



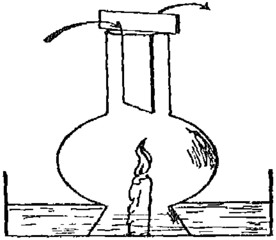
Fill bottle with hot water that has been coloured deeply with ink.

Now fill a large glass jar with very cold water. Rinse off the ink bottle and quickly place it on the bottom of the large jar. Observe and explain what happens.

4. *How does air get heated ?*

(i) Recall or make pupils observe the hard surface of a tarred road in the noon and see the wavy movement of air near the surface.

(ii) Fix a burning candle on a trough. Fill it with a little water. Cut a piece of card board of the shape of T which can fit on the top of a lamp chimney.



Now first put the lamp chimney over the candle flame. What happens after a few moments ?

Then take the chimney out, re-light the candle, put the card board 'T' over the chimney and then place the chimney over the lighted candle as shown in the figure. Observe if the candle continues to burn or not.

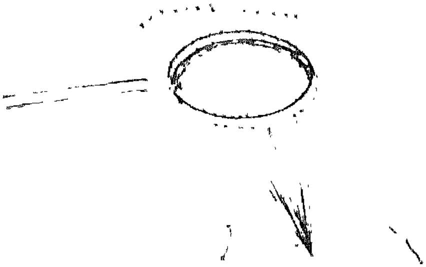
Then bring a piece of smouldering paper near the mouth of the chimney. What does the movement of smoke indicate ? This shows that there is actual movement of air particles in a particular direction. This is called a convection current. Convection requires a medium, liquid or gas.

5. *How does the heat from the sun reach the earth ?*

(i) Stand near a fire or stove. Can you feel the warmth ? Interpose a piece of card board between your face and the fire. Can you still feel warmth ? Why can you not feel the warmth ? Does the heat of the fire heat the air between you and the fire ? Why is the heat cut off by the obstruction ?

(ii) Take a hand lens in the sun. Put a paper below the lens and adjust the lens so that a sharp image of the sun is formed on the paper. Hold for a few minutes and observe what happens to the paper. Where has the heat come from ? Feel the lens and see if it is also hot.

Let the pupils conclude that the heat of the sun and the fire has come without heating the lens or air. This kind of heat is called radiant heat

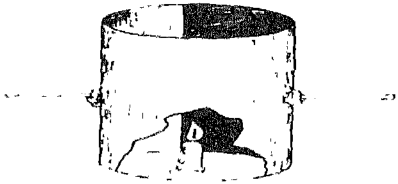


and the process of transmission is called radiation. Radiation does not need any medium.

6. *What are the properties of radiant heat?*

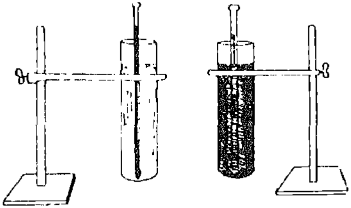
(i) Reflect the sun's rays by a mirror on the face of a pupil. Does he feel the sun's warmth? This is reflection of heat.

(ii) Take a pound size tin or any other container like it. Make two vertical lines opposite each other to divide the surface in two parts. Blacken



one half of the inner surface by a black paint or soot. Keep the other half shining. On the outer surface fix a match stick by a little droplet of wax in the middle of the blackened and shining surfaces as shown in the figure. Then light a candle smaller in size than the tin and fix it in the centre of the tin. Observe after a while which of the stick falls earlier. Why does the stick fall? Which suface absorbs heat quickly?

(iii) Take a test tube which is mirrored from inside. (This can be readily done by warming a little glucose solution with ammonical silver nitrate in the test tube and then throwing away the solution and drying the tube). Blacken the outer surface of another test tube by depositing soot from a candle flame.

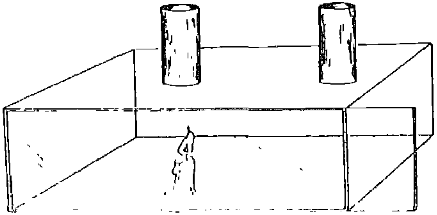


Put equal amount of hot water in both test tubes and put a thermometer in each.

Observe which test tube cools earlier. Which test tube has given away more heat ? The giving away of heat is known as radiation.

7 *How are winds formed ?*

(i) Make two holes in a chalk box or a card board box as is used for packing shoes. On the open side fix a glass by cutting a vertical slit to serve as window. On the holes fix two lamp chimneys or hollow paper cylinders as shown in the figure. At the bottom of one cylinder fix a candle, light it and insert the glass through the slit.



Bring a smouldering paper or rag near the two openings by turn. See what happens. Account for the movement of the smoke. Let the pupils deduce that air on warming becomes lighter and rises up.

Its place is taken by the air from surrounding areas causing a movement of air. This is wind

8. *How does the thermos flask work ?*

It is best for children to observe first that a hot thing keeps hot and a cold thing keeps cold for long hours in a thermos flask. Let them come to a conclusion that a hot thing becomes cold by losing heat to the outside and similarly cool thing gets heat from outside to become warmer. Therefore, the thermos flask prevents both as seen from its use for keeping both hot and cold things.

Then get hold of an old or broken thermos flask and let pupils observe the following features :

(*a*) The vessel is made of glass and is double walled

(*b*) There is a place at the bottom where the opening has been sealed. Tell that air has been taken out and the opening sealed at this point.

(*c*) Both the inner and outer walls are silvered from inside

(*d*) The bottle or the vessel is supported on cork or felt pads and closed with a cork

Let them discuss how heat can be prevented from getting in or out by any of the three modes of transmission.

IV ANSWERS TO QUESTIONS AND PROBLEMS : CONCEPTS

Functional knowledge of facts, concepts and principles. 1	Development of Skills 2	Development of appreciations and interests 3
1 Heat travels in solids through conduction.	Setting up experiments to test hypothesis.	
Molecular motion of the molecules where heat is received is transmitted to the neighbouring molecules and this continues.		List some good and bad conductors in daily life
2. All substances do not conduct heat readily	..	Explain some common applications of good and bad conductors in daily life, use of blankets, woollen clothes, quilts etc.
3. (*I*) Liquids (except mercury) are not heated by conduction but by convection, i. e. actual movement of heated molecules	..	
4. Since heated molecules become more energized, they rise up, their places are taken by others and a convection current is set up.	,,	Make a model room heater. (Unesco Source Book, p. 136)

1	2	3
		Make a model convection current apparatus (Unesco Source Book, p. 136)
(i) Air is also heated by convection. (ii) Ventilation, formation of wind, ocean currents are some examples of convection current		Make a model ventilation box or ventilation in a coal mine. Appreciation of ventilation mechanism in homes, cinemas, offices (Unesco Source Book, pp 91-92).
5 Heat from the sun reaches us by radiation, i e in straight lines without any material medium.	,,	Stars are visible also due to their heat coming to us as light.
6 Radiant heat (a) is reflected by shining surface (b) is refracted by lens. (c) is absorbed better by black surface	Silvering a vessel or glass sheet.	Compare the differential absorption of different coloured clothes
(d) travels in straight line (e) does not warm the medium. (f) travels almost instantly	Improvising experiments to test hypothesis	Explanation of the use of different coloured clothings in various seasons.
		Radiant heat of the sun comes to us through plants as fuel and food.
7 Winds are formed by convection currents set up due to unequal heating of the earth's surface by various reasons	Visualizing a mental picture of a natural phenomenon.	Making a wind belt map of the globe.
		Make a model of convection current in air (Unesco Source Book, p. 137).
8 The thermos flask is an efficient vessel to prevent entry of heat from outside or loss of heat from inside.	Observation and reasoning	Make an ice box in a double walled tin box or a smaller box fitted in a larger one with non-conducting packing material in between

V CULMINATING ACTIVITIES

1. Ask a pupil sitting in the last row to pass one of the balls from half a dozen balls to the pupil sitting in front of him and let this pupil in his turn pass it to the one in front of him till it reaches the one sitting in the front row. Repeat this till all the balls are transferred to the front row, without anyone moving from his seat.

Then take the balls again and ask a pupil from the last row to take a ball and personally hand it over to a pupil in the front row and thus continue the chain till all the balls are transferred by the pupils of the last row to pupils in the front row.

Finally take the same balls again and ask a pupil from the last row to throw one by one all the balls to the pupils in various parts of the class who may catch them.

Then let the children discuss the three modes of transference of heat with reference to pupils as molecules, ball as heat, and review by analogy the various features.

2. A visit to a foundry or a factory will bring out some of the applications of transmission of heat, like :

(*a*) Use of leather or similar non-conducting gloves to handle hot things.
(*b*) Wooden handle of a soldering iron.
(*c*) Chimney over a furnace to allow hot air and smoke to escape.
(*d*) Exhaust fans near the ceiling for ventilation.
(*e*) Coolers in some engines have metal tubes over which water flows constantly.

VI. QUESTIONS

1. Why are metal utensils useful for cooking ?
2. Why is porcelain or glass vessel used for drinking hot tea or milk in preference to metal vessels ?
3. Examine an ordinary hurricane lantern. Why is the oil tank double walled at the top ? Why are the handles hollow ? Why are there a number of holes below the wick and above the chimney ?
4. Why are land and sea breezes caused near lakes and seas in the afternoon and morning respectively ?
5. Why are two thin blankets warmer than a single blanket twice as thick ?
6. Why is a new quilt warmer than an older one ?
7. Why is a cloudy night warmer than an open night ?

VII. RELATIONSHIP WITH OTHER SCHOOL WORK

Relate with the teaching of winds, weather and ocean currents in Geography. Relate with teaching of craft in making models connected with the topics.

VIII. RESOURCES

Books

1.	Black and Davis	Elementary Practical Physics, p. 255-268. (Macmillan) 1955.
2.	Blough and Hugget	Elementary Science and How to teach it. Part IV. (Dryden) 1957.
3	Carleton and William	Physics for New Age, p. 170-181. (Lippin cott) 1947.

4.	Dull	Modern Physics, p 256-270 (Holt) 1948.
5.	Fuller, Brownlee Baker	Elements of Physics, pp. 207-224 (Allyn and Bacon) 1954
6	Unesco	Source Book of Science Teaching, p 135-138. (Unesco) 1957.

Films

1.	Heat Conduction.	English 12 mts. McGraw Hill Junior Science series.
2.	Heat Convection and Radiation.	English 12 mts McGraw Hill Junior Science series.

Available from Central Film Library N I.A.V.E., New Delhi

SCIENCE ABROAD

SCIENCE INSTRUCTION IN CZECHOSLOVAKIA*

JOSEPH SULA

Palacky University, Olomouc, Czechoslovakia

Adjusting the content of science instruction[1] to the importance of natural science in contemporary civilization is becoming one of the most burning problems of pedagogy In modern society the knowledge of natural science and its practical application is useful in so penetrating and varied a way that a man lacking thorough education in natural science can no longer be considered truly educated. Even a century ago A. I. Gercen, the great Russian writer, had written, 'Without science there is no salvation for the man of our times'. How then can we estimate the present importance of sciences when man, equipped with knowledge of them, is exploiting the energy concealed in the atomic nucleus, launching artificial satellites into the universe, preparing for space flights, transforming organism according to his needs and successfully probing into the activities of his own brain ? Descartes' prophetic words are coming true : 'Natural sciences will make man master of the elements and the forces ; medicine will secure for him perfect health and protect him against infirmities of old age.'

If science instruction in general-education schools[2] is to fulfil its most important tasks, it should above all be given due place in the curriculum, i.e., an adequate number of teaching hours. This demand is based upon three reasons.

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* By courtesy of the UNESCO.

[1] The author understands by 'Science instruction' the teaching of all principal branches of science dealing with inorganic and organic nature, i e , physics, chemistry, astronomy, geology mineralogy, general biology, botany, zoology and biology of man.

[2] The Czechoslovak general-education school is a twelve-year school. It consists of three levels, the first of which comprises five grades, the second four and the third three. Attendance of the first and second levels is compulsory for all children. The third level is non-compulsory

I. *Importance of Science Teaching*

Science teaching has fundamental cultural and educational importance. In Czechoslovakia the importance of science instruction is being evaluated from the point of view of socialist pedagogy in some of the following ways :

Science instruction supplies the pupils with *knowledge* without which they could not find their bearing in life, be acquainted with nature and culture, or prepare for study at technical schools and universities as well as for practical life.

It furnishes the pupils with a system of *theoretical knowledge of nature* —of matter as the general and sole basis of all natural phenomena, organic and inorganic, in brief, of the objects, processes and laws of nature. Man as an organism is likewise a subject of science teaching.

Theoretical knowledge is made inseparable from instruction in its practical application, i.e. in the fields of technology, agronomy, hygiene, etc.

On the basis of knowledge acquired in this way, pupils gain *skills and habits* related to an understanding of nature, a mastery of basic techniques in natural sciences, industrial and agricultural production, the handling of the most commonly used tools, health protection, sanitary habits and the observation of safety measures during work.

In Czechoslovakia, general-education schools try to combine, as nearly as possible, science teaching with practical experience in production. In this way, the great pedagogical idea of polytechnical education, whose main purpose is to teach pupils the practical application of scientific knowledge in industry and agriculture and the employment of the most widely used tools of production is becoming a reality. We would like to demonstrate, with at least one actual example, the change in the content of science teaching introduced by this idea. When traditional teaching in biology dealt with the germination of seeds, it did not go beyond theoretical notions concerning the conditions and the process of germination. Polytechnical education combines theory and practice ; it adds agrotechnical teaching matter dealing with the winnowing and sorting of seeds, the testing of their germination power, the season, depth and methods of sowing ; in addition, it teaches pupils how to test the germination power of seeds and how to perform the sowing.

2. Besides implanting knowledge and skills, science instruction develops *cognitional abilities and interests*.

In placing the pupils face to face with objective reality and requiring the perception of its objects and processes, it develops their ability to *perceive*, and teaches them to observe natural phenomena.

Science teaching provides important training in *logical thinking* ; it offers a rich opportunity for analysis and synthesis, comparison, generalization and systematization, abstraction, induction and deduction. It teaches pupils how to use exact terms to formulate their ideas. Together with mathematics, it leads young people to independent, elastic and orderly thinking.

It awakens and develops interest in nature and natural science, in technology and the work in industrial and agricultural concerns. This is of great importance because it leads pupils to the choice of vocations that answer the needs of society, and provides them with interests to occupy their leisure time.

3. Natural sciences are of tremendous importance in forming a view of the world.

The wonderful scientific revelation of nature now unfolding before our eyes is the outcome of natural sciences. A great many of the problems dealt with by natural sciences are also philosophical problems. Matter and energy, space and time, causality, the nature and origin of life, the origin of man and his place in nature, relations between physical and all these subjects concern philosophy as well as science. That is why philosophical and religious conceptions are so deeply influenced by the most important notions and theories of natural sciences e.g., the heliocentric principle, of the preservation of matter, the theory of evolution or the theory of higher nervous activity. Scientific philosophy dialectical materialism — was established and is being further developed, among other reasons to generalize the most important knowledge in natural sciences.

Socialist pedagogy asks science instruction, as its foremost task, to teach the *rudiments of a scientific view of the world.*

Science instruction that is firmly grounded in scientific philosophy establishes in pupils' minds a true picture of nature. At the same time, it eradicates all false conceptions, prejudices and superstitions. It implants the conviction that man can attain full knowledge of nature and that knowledge of its laws enables him to master and to transform it for the benefit of society. It teaches that practice is the basis and aim of knowledge and the criterion of truth. It teaches the study of natural phenomena in their mutual interaction, in motion and development, i.e., it demonstrates the use of the general scientific method- the method of Marxian dialectics. It builds an active, creative attitude towards nature, an attitude that is not satisfied with mere knowledge of reality but strives to transform it.

4. Science instruction also contributes considerably to *moral and aesthetic education.*

It shows pupils the importance of true knowledge of nature, and therefore of truth in general. It convinces them that the aim of science is to build a socially just society as well as to preserve peace. It sets before them the lives and work of great scientists as models to imitate. Laboratories, workshops and gardens provide increased opportunity for work and education. Through work, science instruction kindles patriotism in the pupils by imbuing them with love of their native soil, by acquainting them with the work of outstanding natural scientists, technicians and inventors in their mother country and by pointing to the success achieved there by science and production. It teaches them how to perceive and appreciate the beauties of nature and interests them in its active conservation. Biology instruction contributes to sex education.

II. *Extensiveness of the Natural Sciences*

Another reason for giving them due place in the curricula of general education schools is the extensiveness of subject matter in natural sciences. This extensiveness is due, first of all, to the fact that natural-science classes in general-education schools have to include the rudiments of all principal natural sciences ; i e., the essentials of physics, chemistry, astronomy, geology, mineralogy, general biology, botany, zoology and the biology of man. The teaching of each of these sciences contributes uniquely to the pupils' general education. Thus a general-education school neglecting any of the principal natural sciences would not fulfil its duty.

All principal natural sciences are to be taught in two cycles, viz , both in the second and the third levels of general education schools. We insist that all the principal natural sciences are taught as early as the secondary level because if any of them were omitted at that level, pupils who pass through the first and second levels only would have considerable gaps in their general education. That they should be taught also in the third level schools is reasonable because the pupils' mental maturity and previous training prepare them for *higher* general education in natural sciences to the extent required by universities and practical life.

III *Necessity of Application of Method and Forms of Organisation*

Another reason for a proper time allotment to natural sciences in the curriculum of general-education schools is the fact that science instruction necessitates the application of methods and forms of organisation that are very time-consuming. Demonstrations of specimens, experiments, laboratory work, work in workshops and school gardens, field excursions, and inductive methods in forming general natural-science theories all require considerable time. *Only when sufficient time is granted to science instruction will it be able to realize its potential educational values.* Only then can it include all elements essential for general education, as well as *apply really effective pedagogical methods*

PLACE OF SCIENCE TEACHING

The place of science teaching in the Czechoslovak twelve-year general-education schools is illustrated by the following extract from the curriculum that is at present being tested (Table I)

TABLE I

Subject of teaching Grade	Level I 1, 2, 3, 4, 5,	Level II 6, 7, 8, 9,	Level III 10, 11, 12	Total Number of lessons
	Number of lessons			
Nature and society	3 3 3 4 5	-	-	18
Physics	-	2 2 2 2	2 2 3	15
Chemistry	-	- 2 2 3	2 2 2	13
Biology		2 2 2 2	2 2 1	13
Handicrafts	1 1 2 2 2		-	8
Rudiments of productive activities		3 3 4 5	10 10 12	47

Teaching of astronomy is included within physics, mineralogy within chemistry, and geology within geography. Closely connected handicrafts in the first level and rudiments of productive activities in the second and third levels are taught with natural science subjects. These contribute to polytechnical education. The rudiments of productive activities from the 6th to the 9th grades consist of activities in school workshops and school gardens; from the 10th to the 12th grades they comprise productive activities in industry or agriculture accompanied by the corresponding theoretical instruction.

Hand in hand with the necessity of raising the number of lessons in natural sciences goes the need for *a most careful selection of natural science teaching matter*. This should *include items of verifiable importance for general education* and exclude those of interest to specialists only. The basic problem is *the selection of criteria by which the material for general-education schools ought to be selected from the enormous knowledge gathered by natural sciences in the course of their development*.

ERRONEOUS CONCEPTIONS

Before dealing with this problem we must dispense with some erroneous conceptions regarding the selection of material.

1. Pedagogists often maintain that natural-science curricula can and should vary from school to school because the teacher must *select the subject matter in accordance with the interest of his pupils as well as with his own interest and abilities*.

We cannot but strongly object to this opinion.

The selection of natural-science material for general-education schools is an extremely important responsibility. At the same time it presents an extraordinarily difficult scientific problem that can be solved only by the co-operation of pedagogists, natural scientists, experts in industrial and agricultural production and other specialists. That is why its solution cannot rest upon an *individual teacher*, however efficient he may be. Still less should he select the material according to his individual interests and thus cultivate at school his personal hobbies to the detriment of the pupils' general education.

Even less acceptable is the view that this selection should follow *the interests of the pupils.* A pedagogist from a country where curricula are subjected to extensive investigation, dealt with in scientific papers and discussed by experts, must consider this view eccentric. He finds it absurd that the interests of young people—highly diverse, changing and limited by lack of experience—should play a decisive role in the solving of a problem that, from the social point of view, is of such vital impotance and from the scientific point of view, so difficult to solve. Based upon this mistaken premise, the view simply fails to comply with its social function, for it is empty and unsystematic.

The pupil's interest in his lesson is, of course, a very important condition of success in school instruction. But respect for such interest cannot tell the teacher *what* he should teach. It only helps him to know *how* to teach what the pupil must learn to benefit both society and himself. Besides, the school can easily satisfy the pupils' individual interests and needs by offering an ample choice of non-compulsory subjects.

2. We often hear the opinion that it is sufficient to select out from a natural science just a few topics or problems which reveal its 'essence'.

Every science consists of two components combined into a dialectical unit : one, a body of knowledge, and the other *scientific methods.* The 'essence' of the methods of a given science may perhaps be demonstrated within the bounds of some isolated part of it. But the 'essence' of a body of knowledge cannot be expressed by any or its isolated parts. The assumption that a pupil may learn the 'essence' of physics by studying only acoustics or optics, for example, is entirely wrong.

A still more serious objection can be laid against this opinion. The most essential feature of general education, in contrast to vocational education is its *many-sidedness.* As a consequence of this fact, the pupils have learnt the essentials of the *whole* science, not merely of some of its fields. We cannot speak of satisfactory general education in biology, if the pupils learn the taxonomy of plants and animals without studying their physiology.

A survey of a whole science need not result—as often contended—in didactic materialism, an encyclopaedism, which overburdens instruction with innumerable disconnected pieces of knowledge from various sciences, whether essential or unimportant. It is true that science teaching, as we understand it, offers knowledge from all in the chief natural sciences and their main branches, but it only selects the essentials and links them by fundamental ideas into one organic whole.

CRITERIA FOR SELECTION OF TEACHING MATERIAL

Let us now proceed to the question of the *decisive criteria for the selection of general education teaching material.*

The first, rather general, criterion is that the contents of instruction be in harmony with educational aims. In other words, science material must be so selected as to make possible the attainment of educational objectives. The more accurately and concretely these objectives are stated, the more correctly and easily can materials suited to them be selected. Vagueness as to educational objectives will result in the inclusion of many unsuitable items, thus contributing to the overloading both of the curricula and the textbooks. The selection of materials should always be preceded therefore by a precise statement of educational aims.

The second criterion for selecting science material is its contribution to forming a scientific view of the world. We must first of all select the so-called 'leading ideas' or 'great scientific truths' of every principal natural science. They are the general, often the most general, bulk of knowledge in a science concepts, laws, principles and theories that embrace wide areas of natural phenomena if not all of nature, and join them in a single unifying point of view which explains the greatest possible number of phenomena. Such material as the law of the preservation of matter, the law of preservation and transformation of energy, Mendeleev's law of periodicity, the evolution theory, the thesis that the brain is the organ of thinking, and that thinking is a function of brain is fundamental in forming the pupils' view of the world. After the selection of leading ideas of a science comes the selection of knowledge subordinate to them and increasingly less general. This selection finally gets to concrete ideas and elementary concepts which children should be taught in science lessons at the primary-school level. In this way, a system of notions extends through all levels of general-education schools, aimed at reaching the final goal either directly or indirectly. This final goal is the pupils' conscientious acquisition of the leading ideas of a natural science. The correct selection and interpretation of subject matter direct all instruction in natural sciences towards apprehension of main scientific ideas. Instruction is thus furnished with a distinct ideological goal and an international logic.

The third criterion is that, when selecting teaching materials it is necessary to choose such knowledge and skills as are of *special importance for practical life*. The relationship between theoretical and practical teaching material must, of course, accord with *the principle of unity of theory and practice*. Under-estimation of theory leads to mean empiricism, narrow practicality and utilitarianism. Under-estimation of practice, on the other hand, leads to idle theorizing, intellectualism, academicism, and a detachment of school from life.

The fourth criterion for selecting teaching material is its *contribution to the moral and aesthetic education of the pupils*. Notions and skills related to the protection of nature enter here.

Finally, the fifth criterion: only such matter may be included in science instruction as is *adequate to the mental age of the pupils and in harmony with their previous schooling both in natural sciences and other subjects.* This criterion decides not only the teaching material but also the depth at which it will be taught. Instruction which does not take due account of the fitness of pupils is merely a waste of time and a cause of bad marks.

There may be other subordinate criteria pertaining to serve all natural sciences Nevertheless, the principal criteria stated above can do most to remove purposeless items of science instruction—items that are isolated from any relation to practical life, and are educationally irrelevant or inadequate to the pupils' mental age

It is obvious that the selection of material must be solved not by subjective opinions but through serious investigation of work.

Only after making a very careful selection of natural-science material can the amount of time allotted to natural sciences in the curricula be decided. The number of lessons must be determined by objective scientific methods. It is necessary to state the time required for instruction in individual science subjects, i e., for each topic apart and for the whole course *when taught by methods that promise the best possible educational results and are at the same time, economical as to time, material and energy spent* There are two tasks to be faced: to find teaching methods suitable to the two requirements mentioned above and to determine the time needed for teaching by those methods.

If the school curriculum can provide the amount of lessons judged indispensable for natural sciences, our ideal will have been achieved. If not, the following alternatives remain. The first is to reduce teaching material—even if it has already been strictly limited to items of unquestionable value for general education—to an amount that can be fully handled in the time allotted to the subject. The second is to keep original quantity of teaching material but have it taught by methods that are both less time-consuming and less efficient. There is no need to state that both solutions have serious defects but that, at a pinch, the first is preferable to the second.

In conclusion, I should like to express my personal belief that at present, in what is often called 'the scientific era' or 'the beginning of the era of atomic energy', the curricula of general-education schools need thorough *re-evaluation in order that natural sciences be accorded a place* in accordance with their presentday importance No school can neglect this urgent need without leaving the state whose citizens it educates far behind other countries in all those fields whose successful development depends on proper science education.

THE INFLUENCE OF PROGRESS IN SCIENTIFIC KNOWLEDGE UPON THE STUDY OF SCIENCE IN BELGIAN SECONDARY EDUCATION

W. SERVAIS

President, Belgian Society of Teachers in Mathematics

1. *Modification of the Secondary Educational Structure*

There are two separate school systems in Belgium. Official institutions are maintained principally by the State, and also by provinces and communes ; while the *Ecoles libres* or private confessional schools are under the direction of the Secretariat National de l'Enseignement Catholique.

The secondary educational structure, which includes all schools for young people aged between 12 and 18, consists of general secondary, primary teacher-training, technical and artistic education. This article will be concerned solely with general secondary education.

Official and private secondary studies are divided into two successive three-year cycles : the lower cycle (12 to 15 age group) and the upper cycle (15 to 18 age group). The *Ecoles moyennes* or intermediate schools provide the lower cycles ; institutions giving both cycles are *lycees* for girls, the official *athenees* for boys or for boys and girls, and the private *colleges* for boys.

The intermediate school curriculum is the same as that of the lower cycle in the *lycees*, *athenees* and *colleges*.

Since 1947, under the influence of university science teachers, the pattern of official education has been revised. Alongside the traditional sections of the lower cycle, a Latin-science section slanted towards the natural sciences has been created.

In 1958, teacher-training was reformed so as to include a scientific section B—excluding Latin and having a heavier science programme than the Latin-science section.

Similar changes were made in private education, though in a more conservative spirit.

The number of hours per week given to the sciences throughout the six-year course is to be found in the following table. It includes mathematics as well as the natural sciences, mathematics being essential to any thorough study of the latter.

OFFICIAL EDUCATION

Section	*Mathematics*	*Physics*	*Chemistry*	*Biology*
Latin Greek	444333	011111	001111	221011
Latin-math.	444777	011222	001111	221011
Latin-science	444555	011322	001121	221112
Scientific A	444777	011222	001111	221001
Scientific B	444555	011222	011222	001222
Economics	444333	011111	001111	221001

Pupils in the Scientific Section B may choose, as their option, the course in the history of the sciences and civilizations or an introduction to modern physics (two hours per week during the last year).

PRIVATE EDUCATION

Section	*Mathematics*	*Physics*	*Chemistry*	*Biology*
Latin-Greek	433333	000111	000011	011000
Latin-math.	455789	000111	000011	011000
Latin-science	433444	000223	000111	011111
Scientific A	655789	011211	001011	110000
Scientific B		011223	111333	
Economics	655334	011211	001011	110000

In official schools, the sciences are taught in both cycles, chemistry is spread over both cycles, but is covered in only one cycle of the ancient humanities.

2. *Curriculum and Methodology*

A. Methodological instructions accompanying the science curricula show the spirit in which secondary education has been revised.

At every level, lessons are based on observation and experiments, and the pedagogic of 'rediscovery' is used as an instrument for apprenticeship in the sciences. When, as in official schools, the teaching is spread over two cycles, the first cycle mainly provides an introduction to essential facts, concepts, and procedures. Experiments are performed with very simple material, the pupil being thus encouraged to try them out again on his own account when he gets home.

Even at the beginning of science instruction, activities are not limited to what may be done in the class room. The pupils are taken on biological excursions and on visits to museums, factories and laboratories, with the object of bringing them into contact with the reality of nature and life and awakening in them a taste and enthusiasm for science.

Teaching in the upper cycle, while retaining this experimental and descriptive aspect, introduces increasingly broad synthesis ; the pupil's inductive powers, his capacity to reason by analogy, and all such means of expression as he has been equipped with graphs, formulae, diagrams and mathematical tools are put to use

B. (a) At the lower class levels (sixth and fifth), the course begins with biology. The study of man is based on that of certain mammals. Birds, reptiles, frogs and fishes are compared with mammals. These elements of zoology are rounded off by a summary idea of a few types of Articulata and a protozoan. Botany includes the analysis of simple plants, experimental study of the different parts of a plant, and the classification of these parts into their various types. Means of pollination, dissemination and propagation are considered The essentials of plant and animal physiology are then given.

(b) Physics begins in the fifth class, a purely intuitive glimpse of optics, heat and mechanics being offered. The curriculum of the fourth class takes up mechanics, hydrostatics and pneumatics, electricity, magnetism and electro-magnetism.

(c) Only one hour a week is devoted, in the lower cycle, to chemistry. This is a minimum, entirely experimental programme devoted to air, water, hydrogen, carbon, sulphur, chlorine and nitrogen. Elementary ideas of synthesis are developed in the course of the experimental study.

The curriculum in private education is generally more restricted than in official schools.

In both cases, considerable discretion is left to the teacher.

C. In the upper cycle, more hours are assigned to science courses ; more equipment is provided, and the pupils do practical work.

(a) There are two types of study programmes in physics.

A minimum curriculum of the classic type, taught in the Latin-Greek and Economic sections, begins with mechanics and goes as far as electrical discharges into *rarefied* gases and the thermo-electronic effect.

The intensive curriculum of the Latin-mathematics and Scientific A sections, and especially of the Latin-science section involves a more thorough study of the subject and includes a chapter on periodic phenomena in acoustics, optics and electricity.

The curriculum now being planned for the Scientific B section will include more modern topics : principle of radioactivity ; energy and matter fission, chain reaction ; fluorescence and phosphoroscence ; theories of light ; structure of semi-conductors, and transistors.

When they undertake projects (practical work), the pupils are initiated into the measurement and calculation of errors. In schools, where the new spirit of teaching prevails, science courses are effectively co-ordinated with mathematics courses.

(b) In chemistry, during the second cycle, material studied during the course is dealt with in the laboratory.

The curriculum has a descriptive part and a synthetical part.

Descriptive chemistry includes the study of halogens, nitrogen, phosphorus, carbon, silicon and their compounds. Metals are studied in the laboratory, and an idea is given of the way in which they are worked in industry.

The pupils are introduced both to the qualitative chemical analysis (search for a single body in solution) and to quantitative analysis (volumetric).

In the two new sections slanted towards the science (Latin-science and Scientific B), the curriculum comprises an outline of organic chemistry, covering the hydrocarbons, ethyl alcohol, formic acid, esterification, saponification, the amines, acetamide and urea, proteins, benzene, phenol, and aniline.

The synthetic portion of the course considers the constitution of matter, the laws governing combinations, chemical functions, the laws governing gaseous combinations, the ion theory of electrovalence, the periodic system of elements, the Bohr atomic model, oxidation and reduction, chemical equilibrium, pH, and radioactive disintegration.

Elementary material concerning plastics, radioactivity, nuclear reactions, the constitution of the nucleus, nuclear fission and the atomic pile is optional in the private educational curriculum for the final year

A trend has developed towards introducing the modern atomic point of view immediately by starting with general chemistry experiments serving to illustrate the theory and to introduce the subject-matter of descriptive chemistry.

D. In biology, the upper cycle course provided by official schools takes up the plant and animal kingdoms again, follows the evolution of species and shows their capacities for adaptation to life on land, their manner of living, the relative importance of different groups throughout time, and the effect of all this upon the development of life on earth.

The curriculum for the last year considers cells, the formation of eggs, heredity, the definition of a living organism, the problem of evolution, the unity of the organic world, and a few problems of bio-sociology.

In private schools, except in the Latin-science section, biology is less fully studied, is an optional subject and comprises some ten lessons on general problems embraced in the preceding description.

3. *Laboratories and Equipment.*

The revision of science teaching in a modern spirit has involved the question of laboratories where the pupils may be brought into living contact with scientific facts and methods.

Efforts are being made to provide secondary schools with physics, chemistry and biology laboratory-classrooms, with workshops and with places for collections.

During the early stages of reform, worn-out equipment was restored by the technical centre in Ghent, working in collaboration with an equipment centre which made material for pupils' experiments.

A purchasing commission for science material supplies state schools, according to a definite programme, boys' apparatus in large quantities and checks them before delivering it to the schools.

The Pacte Scolaire law, voted in June 1959, grants, over and above appropriations for current operating expenses and initial equipment, the the sum of two hundred million francs annually for four years, to be used to complete the equipping of schools.

This same *Pacte Scolaire* will make it possible for private schools to obtain the equipment indispensable to them.

4. *Action in Schools in Favour of Modern Science*

Apart from these efforts to improve the curriculum and equip laboratories, action has been taken in schools by the pupils themselves, with the technical help of teacher-advisers. Thanks to related activities, naturalists' groups and science clubs are being formed everywhere ; those take a more direct interest in current scientific developments with which the official curriculum does not yet deal.

One happy consequence of this action was the founding in November 1957, by a group of pupils of the Athenee Fernand Blum, of the *Jeunesses Scientifiques de Belgique*, now consisting of more than two thousand members.

The purpose of this movement is to improve young people scientific education and encourage any inclination to adopt science as a calling. The administration is in the hands of a committee of pupils. Teacher-advisers form the legal administration board of the association, but try to interfere as little as possible and leave wide freedom to the young people's committee.

The Jeunesses Scientifiques de Belgique, publish a monthly bulletin, arrange for important lectures by university professors, and stimulate the activity of their sections in the schools.

The enthusiasm shown by young people in undertaking and making a success of this wholesome initiative proves the firmness of their intentions and offers great hope for their future.

Another efforts to disseminate modern idea is that of the *Association Belge pour le Developpement Pacifique de l' Energie Atomique*. This Association has undertaken 'information campaigns' in schools ever since 1956. In 1958-59, it was reaching 119 groups of 60 to 75 pupils, who were offered three special lectures in their schools : the first on the composition of matter and the principles governing the operation of an atomic reactor ; the second on the production and utilization of radio-isotopes ; and the third on career possibilities. Each group can also take a conducted tour of the *Centre d' Etude de l' Energie Nucleaire* at Mol.

This Association does its work with the help of physics and chemistry teachers, who prepare their pupils for an understanding of the subject-matter presented and the educational films.

5. *Scientific and Pedagogic Activities in Secondary Education*

If secondary education is to be modernized and is to keep in step with modern science, teachers must be briefed, and a constant effort must be made to improve the work they do.

One of the oldest initiatives in the science field is that of the Macleod Congresses-Summer Science Courses for secondary teachers, given by the University of Ghent since 1927.

These annual congresses help teachers to keep abreast of the latest developments and improve the quality of their instruction. During 2 to 4 days, Belgian and foreign university teachers, in 3 or 4 sections corresponding to the various sciences, discuss subjects arranged round a central theme : e.g. spirals in mathematics, crystals, star systems and living beings. The exposes are illustrated by visits to laboratories and factories and by biological and geographic excursions.

The comparable Vliebergh-Sencie summer courses are provided by the Universite Catholique de Louvain.

The Universite Libre de Bruxelles offers to secondary teachers, seminars and lectures supplying advanced instruction in biology, physics and chemistry ; a basis for lessons may be found in the documentary material presented and in the discussion which follows.

The *Association Nationale des Professeurs de Biologie de Belgique* holds an annual exchange of views on developments in the study of this field, on novelties that may be adopted in the purchase and fabrication of teaching materials, and on the organization of experiments. A quarterly publication, excursions and visits help to spread knowledge within the Association of whatever may serve to improve biology teaching.

The "*Naturaliste de Belgique*" Association is concerned with developing knowledge about nature. Its regional members arrange many geo-botanical excursions, accounts of which, together with related scientific information, are given in a publication.

The *Societe Belge de Professeurs de Mathematiques* is working for a better teaching of the 'base science for the natural science' and devotes part of its effort to improving co-ordination between mathematics, on the one hand, and physics, chemistry and biology on the other.

As a study made by the Universite Libre de Bruxelles has shown, all progress in the sciences is contingent on more extensive training in mathematics, not only among such 'heavy' users as engineers and physicists, but also among 'light' users, like chemists, biologists and doctors.

In short, Belgian secondary education, confronted with the advance in scientific knowledge, has modified its structure: two new sections definitely slanted towards the sciences have been created. Curricula and methods, following the reform, have evolved towards active teaching in which the pupil learns fundamental concepts through a personal work of 'rediscovery.' A spontaneous movement, the *Jeunesses Scientifiques de Belgique*, demonstrates the interest young people take in modern science, which, they feel, is penetrating too slowly into the curriculum. Documentation on nuclear energy is being disseminated by the *Association Belge pour le Developpement Pacifiqe de l' Energie Atomiqe* Universites and teachers' associations are making a constant effort to perfect knowledge and methods.

Belgium is engaging more and more in a policy of planned scientific development. It will thus be able, in our expanding world, to maintain a suitable position among the small nations which are the most advanced.

ACHIEVEMENTS OF MODERN SCIENCE AND TECHNOLOGY IN THE SOVIET SCHOOL

A. I. YANTSOV

Assistant Director, Institute of Teaching Methods, Academy of Pedagogical Sciences, U.S.S.R.

The primary function of the secondary school is to train the young generation for full, active participation in the social, cultural and economic life of the country. With the rapid development of science and technology, and their application to methods of production, new responsibilities have been imposed on secondary schools. They must, of necessity, make periodic improvements and changes in the content and method of the instruction they provide.

Many readers are probably aware of the fact that both the secondary and the higher schools in the USSR have recently undergone a substantial reorganization Under the new system of public education the secondary school is divided into two stages. The first, which extends to the eighth grade, supersedes the former seven-year school, while the second stage comprises the 9th, 10th and 11th grades.

These two stages give pupils both general and polytechnical education, but the second stage also provides vocational training. Until now, general education and polytechnical and vocational training were given in different schools, but under the new system they are all provided in the same school during the second stage of education. This is in keeping with the new relationship between general and polytechnical and vocational education, which are becoming more closely and more directly linked, as production increases and with the advance in technical knowledge. This new relationship between general and polytechnical and vocational education in no way diminishes the importance of general education ; on the contrary it demands that its level be raised even higher. General education courses must now provide a sound basis for polytechnical and vocational training, and include a number of new subjects with which pupils must be familiar if they are to understand the techniques and technology of modern production, and the pattern of their future development.

The progress of modern science and engineering dictates the need to improve the teaching of all subjects in the natural sciences and mathematics cycle, and new syllabuses must take full account of the latest achievements of science and technology. Science and mathematics are represented in the Soviet school by physics, mathematics, chemistry, biology and astronomy.

SCIENCE COURSES

The new secondary school programme gives a complete course of elementary mathematics. This mathematics course will comprise not three subjects, as at present, but only two—algebra and geometry. The functional content of trigonometry is part of the new algebra course, and its practical geometric application is part of the new geometry course. This course structure correctly reflects the content and structure of modern mathematics as a science, reduces the number of subjects studied, and allows for better planning of the school curriculum.

More consistently than in the past, the algebra course makes a reality of one of the most important mathematical ideas, the idea of functional dependence, and deals consecutively with the basic functions; trigonometric, exponential, and logarithmic inequalities, and their application to approximate calculations. The study of functions ends with the theme: 'Functions and their investigations; the derivative.' In the study of all types of functions, greater use will be made of illustrations from natural science and engineering. This will make it possible to reveal more clearly the general conception of functions, and the place held by mathematics in the study of natural phenomena and technology.

All this should, we think, considerably lift the theoretical level of the instruction of mathematics, and help to familiarize those important mathematical methods (an understanding of graphics and graphic methods for the solution of problems, the method of approximate calculations, etc.) required for the study of the natural sciences and general technical subjects, and for work in industry.

If greater emphasis is laid upon the functional aspect of the algebra course, more time than was given in the past will naturally be required for the study of its respective parts. The geometry course will include a study of planimetry and stereometry; more attention will be paid to the application of methods of transformation and to the solution of applied problems and the development of space concepts among the students.

During the discussion of the new draft programmes, some of the teachers suggested that the school course in mathematics should include a study of integral calculus and lay more stress on the elements of analytical geometry. This proposal is now being carefully studied.

Substantial changes and amendments have been made in the physics and chemistry courses. These are among the most important natural sciences, and their study constitutes a substantial part of natural science education. The courses include investigation of the simplest and the most commonly recurring phenomena, and the properties of matter; this study is relevant to many branches of modern technology and engineering. We regard the study of physics and chemistry as basic to the most fundamental principles of polytechnical education, and to the training of students for work in the sphere of material production.

The physics course includes a systematic study of all the basic branches of this science—mechanics, molecular physics, heat, electricity, and optics. In perfecting its contents the primary object has been to lift the general theoretical level, and for this reason increased attention has been given to the study of scientific theories—the molecular-kinetic theory of the structure of matter, the electronic theory, and the structure of the atom. The course also includes some new problems of considerable significance in preparing students to understand modern technology better. It is intended, for instance, to acquaint them with certain semi-conductors and electronic devices, and with the physical principles of automation processes ; much more time is assigned to the study of the theory of the structure of solids and the physical properties of various solids, so as to give a better understanding of the problems involved in their physical and mechanical processing. A closer study will also be made of the peaceful uses of atomic energy.

The physics course will also cover the different types of energy used in modern production ; the scientific principles of transformation of energy and its use in industry ; the working principles and operation of various engines (hydroturbines, wind and steam engines, electric motors, etc.) ; an idea of the physical principles underlying the design and operation of various types of transport (locomotives, ships, airplanes, etc.) and communication (telegraph, telephone, radio, television) ; information on the principles used to compute pressure and strength of materials ; information on building techniques and the physico-mechanical properties of certain building materials. During the course, students will learn to make precise measurements of various physical quantities, and to assemble and instal technical devices and use conventional technical laboratory equipment.

The chemistry course will consist, as before, of the fundamentals of inorganic and organic chemistry. The inorganic chemistry programme covers the study of metals, metalloids, and their compounds ; all chemical facts are regarded in the light of the periodical law of D. I. Mendeleev and the theory of the structure of the atom. The organic chemistry course covers the basic classes of organic compounds as well as the properties and structure of high molecular compounds, an idea of their classification, and basic methods of synthesis. The course is based upon the consistent application of the theory of chemical structure. Students will be made familiar with plastics, artificial and synthetic fibres and rubbers, and the most typical processes used in their manufacture.

The chemistry course devotes more attention to questions connected with the principles of chemical production and the application of chemistry in different industries and in the home. The course familiarizes students with the production of acids and salts, building materials, iron and steel, the processing of coal and oil, the industrial uses of natural and oil by-product gases, and offers basic information on the practical application of chemistry in power engineering, machine manufacture, and agriculture. Much attention is given to practical exercises in chemistry.

The astronomy course covers the structure of the solar system, the simplest celestial phenomena, the stellar systems, the origin and evolution of celestial bodies, astronomical determination of the size and forms of the Earth and the celestial and ground coordinates, and the most important modern methods of studying the universe. The course also includes an explanation of the significance of man-made satellites for the investigation of the Earth as a celestial body. All this knowledge will give the student a materialistic conception of the universe.

In Soviet schools much importance is attached to the study of biological subjects, which are taught for five years, beginning in the fifth year. In the eight-year school the principles of botany, zoology, anatomy and physiology of man are studied. At the second stage of education there is a course on the principles of general biology. Until recently this course was based wholly on the principles of Darwinism and the studies of Michurin, but the course is now extended to include the physiology of plants and animals, of importance both for a general culture, and for an understanding of the agronomic principles of agriculture.

The general biology course offers a definite system of knowledge of the nature and laws of development of living organisms and of the principles governing the development and formation of plants and animals. The course also contains information on the origin and development of life on the Earth and the origin of man. The course is accompanied by practical work, chiefly in controlling the development of cultivated plants and domestic animals.

In the study of physics, chemistry, mathematics, and biology, the scientific principles of the techniques and technology of modern production are explained; the students are taught to make measurements, computations, and experiments, and acquire other skills. This is an important contribution to polytechnical training. But polytechnical training in the Soviet school is not limited to this. It also includes such technical subjects as the study of mechanical and electrical devices and techniques.

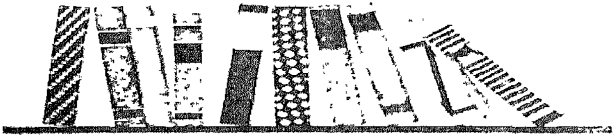
TECHNOLOGY COURSES

The machinery course includes the following subjects: a general acquaintance with the basic engineering materials; machine parts and their combination; the design and work of mechanisms and machines;

their care and control. Students do practical work connected with the taking apart and assembling of mechanisms, and with their regulation. The electro-technical course includes a study of the basic electro-technical materials, electrical measuring materials and instruments, electrical machines, direct and alternating currents and transformers, elements of electronics and automation, generation, transmission and distribution of electrical energy, and some of its application for technological purposes. The machinery and electro-technical courses have a polytechnical character and are closely related to the physics course. In village schools these courses give information on farm machinery and the use of electricity in farming.

Such are the main directions followed by the Soviet secondary school in perfecting natural science and general technical teaching. The fact that more attention is now given to the natural sciences and general technical cycles, and to their further extension, does not mean, however, that the role and importance of the humanities are in the least minimised. As before, they continue to have an important place in the Soviet school, and steps are being taken to raise their level still higher. The principal subjects in the humanities cycle are history, literature and languages, and they figure in the curricula from the fifth school year on.

The Soviet secondary school is expected to prepare highly educated people familiar with the principles of the sciences and humanities and capable at the same time of working in modern industry. A function of the schools is to teach young people to strive to be useful citizens, actively participating in the production of material wealth required by the people This is the fundamental object both of the reorganization of the Soviet secondary school, and of the contents and teaching methods it uses



BOOKS FOR YOUR SCIENCE LIBRARY

In the last issue of the Journal we had given a detailed account of the production of the PSSC book in the U.S.A. The book is the result of the work of a group of top-ranking teachers of physics both at the University and Secondary school levels. The PSSC group brought out the book *Physics* in 1961, and a number of associated materials such as work-books, laboratory guides, a set of inexpensive apparatus, films, tests and teachers' guide. They have published 25 titles in physics at a very low cost to serve as supplementary reading material.

In this issue we introduce our readers to some of these books.

EDITOR]

Pasteur and Modern Science : RENÉ DUBOS

Science Study Series, S 15, pp. 159, 1960.

In the teaching of a science, the history of the science and the biographies of great discoverers are as important as the contents themselves. *Pasteur and Modern Science* is an inspiring account of life of Louis Pasteur and the passionate devotion to experimental science that Pasteur showed. The word 'pasteurization' has become common, and Pasteur has immortalized himself by his germ theory of diseases, his work on anthrax of sheep and the prophylaxis of rabies. As a matter of fact, many laboratories which prepare vaccines against the bite of rabid dogs are named after Pasteur. In a very simple style the author gives an account of the various achievements of Louis Pasteur in the field of microbiology, bacteriology and immunology and his experiments with milk, wine, vinegar and beer. It was his work on these substances that laid low the then age-long belief in spontaneous generation. Besides these accounts the biography also includes details of Pasteur's domestic life, his noble views and high thinking all enlivened by many personal touches. Very often, Pasteur spoke of the 'close correlation that exists between theoretical science and the life of nations'. We cannot overemphasize his advice to the young students, 'Live in serene peace of laboratories and libraries . . .'.

The Physics of Television : DONALD G. FINK and DAVID M. LUTYENS

Science Study Series S 8, pp. 160, 1960.

The book gives an account of the basic principles of television in very simple language.

The first chapter of the book deals with the problem of communication in a general way. The essential criteria for any communication system viz., speed, accuracy, distortion, power and modulation are discussed. The basic ideas of television as sending the picture in code, the necessity of scanning, the possibility of seeing the motion picture due to persistence of vision, which in the present case means transmitting and receiving six million picture bits per second, are introduced.

The second and third chapters provide the basic tools for television. Chapter two starts with the basic question, 'What is light—wave and/or particles' ? The answer supplied is, 'Both tell us partial truths about light'—'Both are consistent with each other'. Moving through the chapter, the authors carry the reader through many fundamental problems dealing with the source of light, the interaction between photon and electron, photoelectric effect and fluorescence. The third chapter starts with a discussion on electric current in solids, gases and vacuum and is followed by a vivid exposition of the relation between current and magnetism leading to the electronic valve and its use as an amplifier and oscillator. The two chapters are extremely well written and explain some of the many complicated physical aspects of the nature of light and electricity and could have formed a valuable part of any book on basic physics. While reading through these chapters one forgets for a while that he is reading a book on television. These chapters cover more than one third of the book and one is apt to feel that the authors while writing a book on television could have safely assumed this knowledge on the part of the reader and should have used these pages for more details of the television system itself.

Chapters four and five bring the reader really in touch with the working of the television system. First, a simple closed circuit television system is described which brings forth the essential features of the television transmitter and receiver. At the transmitting end, the working of electronic cameras—iconoscope and image orthicon, while at the receiving end, the picture tube which finally converts the video signal wave form into moving pictures, is described. The necessity of having the synchronization and blanking pulse is stressed. Next the system is extended to radio television system and the problems of modulation and demodulation are discussed.

The last chapter adds colour to the television. As in other chapters, here also the authors start with the very fundamentals. The question, 'What is colour and how we perceive it' leads to the distinction between physical colour and physiological colour. It is fortunate that the human eye is deprived of the analytical power of perception making colour printing, colour photography and colour television possible. In colour television the additive process is used. The picture screen is coated with three different fluorescent substances which when excited glow with red, green and blue light, respectively. While transmitting, the image to be televised is split up into three images one in each of the primary colours—and the receiver recombines them. The chapter makes it clear that a colour T. V. system is very complex and more delicate than its black and white predecessor. The details of chrominance signal are above the standard of the reader, for whom the book is meant.

The printing and the get up of the book is nice. There are very few mistakes, though one of them is very glaring (p. 82, fig. 11). The resonant frequency is given as $\sqrt{\frac{1}{2\pi Lc}}$ instead of $\frac{1}{2\pi}\sqrt{\frac{1}{Lc}}$), and this could have been corrected very easily.

The book tells the story of television and biography of the main actors therein in a very simple, lucid and interest sustaining fashion. The authors have succeeded well in achieving the aim of the book.

M. K. MACHAWE

Echoes of Bats and Men : DONALD R. GRIFFIN
Science Study Series S 4, pp. 156, 1959.

The book gives a clear idea of how studies of bats, porpoises and whirligig water beetles may help us to apply echoes in our everyday life and how this knowledge may also be applied to help the blind to move from one place to another.

The book starts with animals who use echoes to find their way in the dark and to obtain their daily food. Whales and porpoises swimming in the dark or in turbid water make clicking sounds with frequencies ranging from 150 to 150,000 c. p. s. and can locate a small fish from the echoes received from the fish. Bats flying in air catch their prey by echo-location. Experiments show that bats when blinded can feed on insects just in the same way as any other normal bat. When flying in air they make orientation sounds, clicks of high frequency ranging from 10 to 150 k. c. for different species, each click lasting for a short interval. Whenever they detect an insect, there is a marked increase in the rate of orientation sounds. They catch their prey, very small insects like mosquitoes, very quickly. Fish-catching bats fly just over the water surface and catch fish from inside water surface in the same way. Calculations show that the intensity of the echo from insects or from a fish is extremely small. Water waves and surface echoes have been used by whirligig beetles to move from one place to another on the water surface without collision with any obstacle.

The next chapter deals with the nature of sound waves, their propagation, formation of echoes, etc. Echoes are rarely noticed even though every object reflects sound to an appreciable extent. Experiments have been described to demonstrate echoes using an oscillograph or by using a tape recorder. The second experiment is a very interesting one. Using a toy clicker and placing it at the focus of a paraboloid horn, one may, with care and practice, detect walls or small trees simply from the echoes heard. The method of echoes has been used for the determination of velocity of sound in air

In the chapter on Sonar and Radar is described how sound waves have been used for echo-location. Echo sounders have become almost essential for safe navigation. Using very high frequency sound waves, submarines, icebergs, etc., have been located, the reflected wave and a local high frequency wave producing audible beat notes. The relative motion of the target has also been determined from Doppler's principle. Sound waves through solid materials (and echoes) have been used by geologists for oil prospecting or for detecting different types of rocks. Echo-probing may be applied in the near future to detect discontinuities in the internal organs of human beings and this may have some advantages over X-rays. The use of radar for the detection of distant aircraft by echoes of radio waves has been described and the relative efficiencies of bats and Radar have been compared.

The last chapter deals with blind people and how echoes help them in detecting objects.

S. K. NANDI

Crystals and Crystal Growing : A. HOLDEN and P. SINGER

Science Study Series S 7, pp. 320, 1960.

This is a useful and interesting book written primarily from a layman's viewpoint. It presents a well connected account of known facts regarding the symmetry of crystals, some of their characteristic properties, and some simple methods of growing them. A notable aim of the authors has been to induce the reader to try out a few simple experiments and recipes suggested in the book. For this reason, and the reason that it is intended to be only an elementary text on the subject, emphasis has been solely laid on one mode of crystal growth alone, viz., growth from solution.

The book starts with the concept of the crystalline state among solids. Next, the principles of growth from solution are outlined and the methods of growing crystals of certain familiar and representative substances given. The concluding chapters describe in a simplified manner both the external and internal symmetry of crystals, and some of their familiar properties like cleavage, low melting points, piezoelectric effect, etc. The book also gives a list of advanced text and articles on the subject to interested readers. A few problems are also scattered here and there.

The style of writing is lucid and a special word is due to the simple, yet so illustrative, line diagrams. The book is full of useful illustrations, including many photographs. Some of these are coloured, showing natural colours of crystal. The striking simplicity and clarity with which several rather intricate points in crystal growth have been explained and illustrated, bear a clear stamp of the rich experience of the senior author in this field. A few initial pages pose for a rather abstract start, but the book soon settles down to a well connected account.

G. C. TRIGUNAYAT

Near Zero : D. K. C. MacDonald,
Science Study Series S 20, pp. 116, 1961.

The book gives a popular exposition of the physics of low temperature. It forms part of a series of books written to 'provide a survey within the grasp of the young student or layman'. The book tells us about some of the interesting things that happen or can happen at low temperatures. It is written in a lucid conversational style and holds our interest throughout.

There are five chapters in the book. The first chapter introduces one to the absolute scale of temperature. The second chapter on 'How do we make low temperatures' is very well written and gives a clear idea of the physical principles involved in the production of low temperatures. The concept of entropy is explained and the method of adiabatic demagnetisation is presented in a simple manner with the help of clear line diagrams.

The next two chapters deal with the phenomena of 'superconductivity' and 'superfluidity'. Here the author meets with the difficulties usually present when trying to explain complicated theoretical concepts in an easy and popular way. He has overcome the difficulties in a manner which may not be completely acceptable to a theoretician. The last chapter mentions 'How other sciences make use of low temperature physics'.

The book has a few interesting photographs of the equipment used in a low temperature laboratory and has a useful index.

N. PANCHAPAKESAN

Magnets : Francis Bitter

Science Study Series, S 2, pp 155, 1959

The book gives a lucid and up-to-date account of the subject of magnetism in a non-mathematical language. The autobiographical touch makes reading particularly pleasing.

Beginning in the historical fashion with permanent magnets and their interactions, the author goes on to interpret them in terms of electronic currents in atom ; the same concept is used to distinguish between paramagnetic and diamagnetic substances. Ideas of quantum theory are introduced, specially that of the space-quantization of magnetic moment in an external field, and experiments are described which confirm them.

In the chapter on ferromagnetics, concepts of spontaneous magnetisation and magnetic domains are introduced and magnetic powder experiments, which enable one to 'see' the domains, are described.

The chapter on the production of strong magnetic fields is highly interesting. The author discusses at length some of the difficult problems associated with the passing of enormously high currents through conducting coils, and their eventual resolution.

The book ends with a chapter on the relatively modern subject of nuclear magnetic resonances.

K. K. Singh

How Old is the Earth : Patrick M. Harley

Science Study Series, S 5, pp. 160, 1959.

In this book the author gives an up-to-date account about the age of the earth in very simple, non-mathematical terms. Thus, the matter in the book can be easily understood even by a layman. The style is quite good and sustains the interest of the reader up to the end.

The author lays special emphasis on the earth's radioactivity in the understanding of the problem. He develops this by starting from the structure of the earth and the various geological events which give some clue to this ancient riddle, and ends with the conclusions derived from the study of the origin of solar system. He shows in quite a lucid manner that radioactivity is a very important tool for a geologist.

R. Chandra

Water The Mirror of Science : KENNETH S. DAVIS and JOHN ARTHUR DAY
S 18, pp. 195, 1960

The author opens the first chapter by talking in detail about the unusual properties of such a 'usual' substance as water. In very simple style he explains the molecular theory of matter and its three states. He explains the unusual boiling and freezing points of water, its maximum density at 4°C, the remarkable heat capacity of water, and the use of these unusual qualities in nature. The unusual use of water as a solvent, its surface tension, and its use in nature have been well explained.

Chapter two describes the discovery of the composition of water in a historical style In the third chapter the author discusses the causes of these unusual properties of water. He begins by taking up Dalton's theory and the concept of atomic weight and talks of the Mendeleef's table and periodic law He then takes up the physicist's concept of an atom, describes J. J Thomson's experiments and M. Curie's discovery of radium. In a historical style he traces the development of the modern concept of the atom, describing the experiments of E. Rutherford on scattering of the alpha particles, and Bohr's theory to establish the structure of the hydrogen atom. He then explains the modern periodic table.

Turning to the chemical bond approach in the constitution of water molecule, he explains why water would not be easily ionized. He mentions the unusually large dielectric constant of water, and its unusually large property as a solvent The hydrogen bond in the water molecule has been explained as providing the extra force to bind the water molecule together, than the mere Van der Waal's attraction. The unusual properties of water explained by the hydrogen bond are, for example, floating of ice, large heat capacity, etc

In the fourth chapter the author introduces the new isotopes of hydrogen and oxygen, the heavy water, and talks of the presence of eighteen different compounds in a sample of so-called pure water. He then explains 'nuclear fission' and 'chain reaction', and the use of heavy water as 'moderator'. He also talks of the possiblities of nuclear fusion.

In the fifth chapter the author decides the age of the sun and the earth from the rate of disintegration of the radioactive elements, and other evidences. He then explains how the peculiarities of water caused by hydrogen bonding made it by far the most important terrestrial agency for the geologic modifications of the earth's surface.

In the sixth chapter he talks of the possibility of life on other planets, and goes to trace the origin of the life itself. He then talks of the problem of the availability of water created by man by his excessive use of the usually obtained 'unusual' substance 'water'.

The author concludes by saying that the natural world reveals itself as a flowing reality analogous to a river. 'Like a river', it is paradoxical in that, it is continually ceasing to be what it is becoming, what it is not, while yet remaining what it always was. The book provides an engrossing reading for all and is within the competence of a student of science at the Higher Secondary level also.

R PRASAD

The Restless Atom : ALFRED ROMER

Science Study Series, S 12, pp. 198, 1960

This book describes the historical development of the theory of the atom, particularly the nature of radioactivity, transmutation of elements into different isotopes and the chain of events which helped in understanding the structure of atoms

Starting with the experiments of Roentgen with X-rays in 1896, it describes the findings of Henri Becquerel about the penetrating rays emitted by uranium and its salts. A detailed account is given of the discovery of new radioactive elements, polonium and radium, by Marie and Pierre Curie and experiments on the decay and build-up of short-lived radioactivities from thorium oxide and uranium by Rutherford and Soddy and Crookes. Next follows the series of experiments performed in different laboratories which led to identification of α and β rays from uranium, the number of α particles emitted per gram of radium, the charge of an α particle and finally the transmutation chain of radium and actinium. Later it was established by Rutherford and Royds that α particle is the same as the helium nucleus From experiments on the scattering of α particles by lead, Rutherford got the first clue of the model of atoms.

Elaborate spectroscopic and chemical studies on the decay products of radioactive elements resulted in the discovery of isotopes by Soddy, and by 1912, every known radioactive element could be fitted into the Periodic Table.

Finally Bohr gave a model of the atom, based on Rutherford's earlier model, which became the starting point of modern atomic theories.

The book is written in an interesting and readable style describing chronologically all the experiments performed by different workers which cleared the way for understanding the atoms. It will serve as a good introduction to the subject for the beginner

V. P. DUGGAL

PHYSICS For the Modern World E. N. DA C. ANDRADE
CHEMISTRY For the Modern World. GEORGE PORTER
BIOLOGY For the Modern World C. H. WADDINGTON

Science for the Modern World Series. George G. Harrap & Co. Ltd., London, Oxford University Press, 1962. Each 4s. 6d.

Science today has progressed so much that it is difficult to keep pace with the advancement of knowledge in the various disciplines. The common man takes for granted several scientific marvels, which were unknown to his forefathers. The sputniks and the adventures into space, for example, were unknown and considered very difficult to achieve only two decades ago.

Attempts are made in schools today to give every child a balanced education, and the teacher has to know a little of every science, so that he can answer the queries of his wards. These three books, each written by an eminent scientist, state the principles of the basic sciences, in clear and simple language and the teacher who has gone through these books will be better equipped to explain the several advances in the three sciences.

There are two methods in which a science can be described, one is to describe from above downward and the other from below upward. All the three sciences dealt with here are so well advanced that the latter method is adopted, i. e. to begin with an account of the fundamental units and work gradually upwards towards everything around us.

The first book, on physics, begins with matter and motion and ends with a chapter that is devoted to the atom and its structure. In between familiar physical phenomena are described in simple and lucid language.

The second volume, on chemistry, begins with atoms and molecules and their structure. The concluding chapter on 'Chemistry as a Servant of Man', is very instructive as it deals with fibres, plastics and rubber, dyes and drugs, and soap and water, to mention only a few.

The third book on biology, is written to provide a general account of the science in a form which requires no previous scientific knowledge. The book begins with description and structure of enzymes and genes, and after dealing with various other features, it ends up with an account of evolution.

There is a thought-provoking foreward by Dr. Radhakrishnan, President of India, who says that science and technology have vastly increased our capacity to shape our life for good or evil. If rightly used, these powers can give us strength, a fuller freedom and a better life, and if abused they can bring about chaos and destruction. The present is a period of testing. Everyone would agree with these views.

S. DORAISWAMI

PLANTS AND HUMAN HISTORY

P MAHESHWARI

University of Delhi

There is often an impression in the mind of the layman that the study of botany is an innocent pastime peculiarly suited to the female sex because of the nice colours, elegance, and fragrance of flowers and plant parts. They do not soil their nice dresses, nor give out the foul smells characteristic of a laboratory dealing with animals. There is also not much danger of burning the hands, or of having to exert the brain with difficult mathematical probems as in physics and chemistry

All of these premises are false as botanists will no doubt appreciate and understand at once As I shall try to show, for obtaining plants men have gone forth with the sword to distant lands, set upon long voyages of discovery, and conquered new lands. In fact, even in the modern world, plant power means as much or more than water power, sea power, atomic energy, and so on.

QUEST FOR SPICES

Of considerable significance in this connection are the spices. Common-place though they are today, the history of their cultivation and transport is a romance which includes accounts of geographical discovery, economic warfare, annexations of territories, and all the vices of theft, envy, hatred, and subterfuge which the human species is capable of.

There was a period in history when India was a prosperous country, flowing with 'milk and honey'. The economy of the people was sound and from the evidence of foreign visitors like Megasthenes it appears that famines never occurred those days. Of its plant resources, pepper (*Piper nigrum*) was among the most important from the international point of view Two thousand years ago only kings and the wealthiest nobility could afford its use. In Rome during the first centuries of the Christian era it was measured out in balances for its equivalent weight in gold. In 408 A.D. when Alaric the Goth captured Rome and massacred many of its citizens, he demanded as his tribute 5,000 lb. of gold, 3,000 lb. of pepper and 30,000 lb. of silver. Attila (406-453 A.D.), King of the Huns and Scourge of God, as he was called, demanded 3,000 lb. of pepper as part ransom for the city of Rome. In medieval Europe pepper was held in such high regard that landlords readily accepted rents in pepper. It ranked as a commodity of standard value just as tobacco was legal tender in colonial Virginia. Kings presented pepper to each other and it was received most cordially. Hermann (1958) in his book, *The Great Age of Discovery* writes: 'Custom duties, rents and taxes, even court fines were paid in pepper. It bought ground and land, paid off mortgages, could buy burghership and coats of arms. The most beautiful women, the noblest horses, the most brilliant jewels, precious carpets, rare furs: all these could be had for pepper.' Many other spices were also held in high regard. A single pound of ginger could buy a sheep, and a pound of cloves could buy seven sheep. In Rome, on special occasions, the streets were 'fumigated' with cloves; and it was the custom in China to hold a clove in the mouth if anyone wanted to speak to the Son of Heaven.

At first it was the Persians who took spices from India by caravans and sold them to the Phoenicians of Sidon and Tyre who traded in them all along the Mediterranean coasts from Alexandria to Rome. From the first to the eighth century Indian and Greek traders held the monopoly. Later, the Arabs took up the trade and sold the spices to Venetian traders in the markets of Damascus, Instanbul and Beirut. Arab sailors ventured far out to the East into Ceylon and the Moluccas. The Venetians of those days spoke of the 'spices of Araby' knowing little about their real origin. Later Malacca and Malabar were considered to be the homes of cloves and nutmeg, when in reality they came from farther east and India was only the wholesale shipping agent for some of these products. The Arabs closely kept the secret and obscured their account with tales of terrible sea-monsters and wild animals which not even the bravest of the Venetians dared to see for himself.

It was not until Marco Polo (1254-1324?), a boy of 15 years, went with his father and uncle to China, and brought with him an account of the treasures of the Orient (the ginger and camphor of China, cloves and nutmeg of the Pacific islands, cinnamon groves of Ceylon and the pepper vines of Malabar) that the Europeans began to have some idea of oriental geography and the spice treasures of the East. The prosperity of Venice, resulting from her trade with India, was a matter of extreme jealousy to the other European powers who were anxious to get direct to India without the intervention of Venice or Egypt. Columbus (1451-1506) sailed westward but discovered America instead of India. Inspired by Prince Henry the Navigator (1394-1460)[1] the Portuguese sailors were at the same time pushing farther and farther down the coast of Africa. In 1497 Vasco da Gama (1460-1524) rounded the Cape of Good Hope (formerly called the Cape of Storms) and then reached Mozambique in March 1498. His ships reached Malindi at the end of April. Guided from there by a Gujarati pilot he landed a few miles north of Calicut on May 17, 1498,

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[1] Henry himself navigated no ships and never went beyond the straits of Gibraltar, but he greatly promoted maritime exploration and was keen to find an all sea route to India with the object of circumventing the Red Sea route which was under the control of the Arabs and the Egyptians.

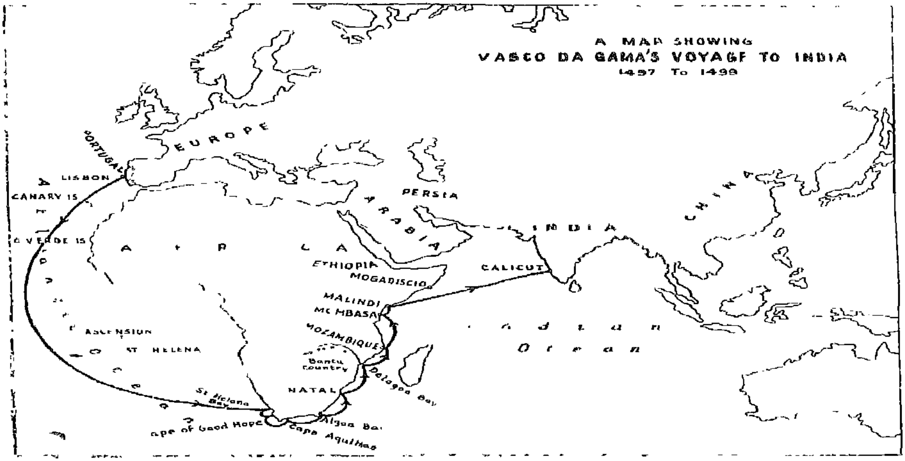


Fig 1 Map showing route taken by Vasco da Gama for going from Lisbon to Calicut.

after a strenuous voyage of nearly 11 months in which more than half of his men died of scurvy (see Fig. 1 for route followed by Vasco da Gama). The importance of Vasco da Gama's discovery lay in that it broke the monopoly which the Egyptians and Venetians held for several hundred years in the trade with India. Very soon the Portuguese came into conflict with the Arabs whom they ousted from the Indian shores, and later with the Indian princes who were silenced by gunfire. Encouraged by their successes and the superiority of their arms the Portuguese seized the coastal areas of Ceylon with its great cinnamon forests and founded 'a brave little empire over half a year's journey from the homeland'. They made a law—the disobedience of which was punishable by death—that no native could cut a single foot of cinnamon bark or sell it except under the orders of the conquerors. On the Malabar coast they captured Goa and built a large warehouse and fort. Among the articles they took from India were pepper, cardamom, cinnamon, ginger and coir for making ropes for their ships. Portugal was then at the zenith of her power. She was mistress of the seas and the maritime capital of Europe. On the western side she had discovered Brazil, on the eastern side she went further, seized Malacca, key city of the Indian seas; and then the Moluccas or Spice Islands. D. Peattie says in his fascinating book entitled, *Cargoes and Harvests*, 'Great was the wealth of the Portuguese East India Company and exorbitant the profits it reaped. With slaves to gather the precious spices, without a rival on the Indian seas, the company poured into the [illegible] Lisbon such wealth as that old city had never dreamed of'.

However, the small country was not able to hold its far-flung possessions for a long time. The Dutch and the British mercilessly attacked its fleets everywhere and in 1581 the Portuguese crown was united with that of Spain. The Spaniards preferred the Atlantic and the rubies and gold plundered from the Aztecs and the Incas than the spices of the Orient.

In 1594 the leading merchants of Holland held a meeting at Amsterdam and decided to send a Dutch fleet to India. A company was formed and a fleet of 4 ships left for India in 1595. In 1599 the Dutch had already established an eastern trade and then came the British. Like ants following a cube of sugar, the Dutch sailor trailed around the Cape of Good Hope to India, and then went on to Malacca and finally to the Spice Islands. One by one the Portuguese possessions fell. As Panikkar (1929) says: 'Challenged on the sea both by the Dutch and the English and hated by the Indian powers, the Portuguese fought a losing battle'.

Ruthless and inhuman in their relations with the native inhabitants, the Dutch did the job even more thoroughly than the Portuguese. Wealth poured into their little country as it had done before into Portugal. Large and beautiful buildings were erected, fashionably dressed men and women paraded the streets, men lived in ease and idleness and 'there sprang up in Holland a galaxy of painters, musicians, scientists and poets'. Persia, Phoenicia, Arabia, Damascus, Venice, Lisbon and now Amsterdam flourished by turns under the Midas touch of spices.

Holland's genius burned for a century. Other European nations were jealous, and in 1770 Poivre, the French Governor of Mauritius, smuggled cloves and nutmeg out of Moluccas to his own province. From there the plants were taken to Zanzibar and the West Indies. The Dutch monopoly was broken, although they continued in Indonesia until 1947 and still made great profits in various ways.

The British were at first friendly to the Dutch but after the Portuguese were put out of action, they changed sides and for many years there were naval and land clashes between the British and the Dutch. In 1786 the British got a grip on Penang, then on Singapore and later on Hongkong. The British East India Company conquered almost the whole of India which passed on to the British Crown in 1857 and remained a part of the British Empire until 1947.

MUTINY ON THE *BOUNTY*

Many people have heard of Captain Bligh's voyage to the island of Tahiti and the rebellion of the crew of his ship *Bounty* This has figured in several novels and even a cinema film has been made of it Not all know the object of Bligh's expedition, however In the 18th century the British planters in the West Indies had devoted large areas to the growing of sugarcane. For their slaves it was necessary to have some cheap food and the planters thought that they had found an answer in the breadfruit (*Artocarpus incisa*), news of which had been brought to England by various south sea explorers including Captain Cook. Like the jackfruit, this is a large tree and the fruits grow on boughs like apples. When ripe they are yellow and soft with a pleasant taste Being in season for eight months in the year, the tree formed an important food for the natives in the South Pacific islands. The planters of the West Indies were attracted Sir Joseph Banks, then President of the Royal Society and himself a botanist, persuaded King George III to charter a ship under Captain Bligh who had once accompanied Cook and took a keen interest in natural history. Two horticulturists of the Kew Gardens were sent with him to tend the plants on the return journey. The *Bounty* sailed from England on October 15, 1878. Due to wind and currents she failed to round Cape Horn and had to be turned eastward reaching the Cape of Good Hope on May 22. From there it went to Tasmania and it was only on October 24, 1788, after a full year, that it reached Tahiti. Bligh gave to the natives the seeds of melon, cucumber, some stone fruits and almonds, and took from them young plants of the breadfruit. On April 4, 1789, five months after its arrival at Tahiti, the *Bounty* set off for the West Indies. However, the sailors had taken native wives and begun to enjoy life on the island. They were most unwilling to return. Bligh's treatment of his men had been rather high-handed and he used to award stern punishments for comparatively small offences This had caused resentment in the minds of many. At the same time it appears that he had not chosen his crew carefully. A good proportion of them were an irresponsible lot who preferred a life of ease and luxury rather than face the danger of the sea. On April 28 the bubble burst and the famous mutiny broke out. The rebels threw the precious cargo overboard and in a few hours the breadfruits were floating in the Pacific. Turned out by the mutineers Bligh, along with a score of loyal followers, performed a voyage of 3,600 miles in an open boat. This has become one of the epics of the sea (Fig. 2).

In October 1790, the mutineers were court-marshalled ; and in December, 1792, Bligh started on a second breadfruit voyage. His ship, *Providence*, arrived at Tahiti on April 8, 1793. On July 18, it left with [illegible] potted breadfruit trees and about [illegible] other plants. Only a fraction of these survived and could be delivered to the islands of the West Indies. Bligh was made a Fellow of the Royal Society in 1801 in consideration of his distinguished services to navigation and botany and later promoted to the rank of Vice-admiral. Although the breadfruits thrived in their new setting, the planters' dreams remained unfulfilled for the negro slaves did not relish them.

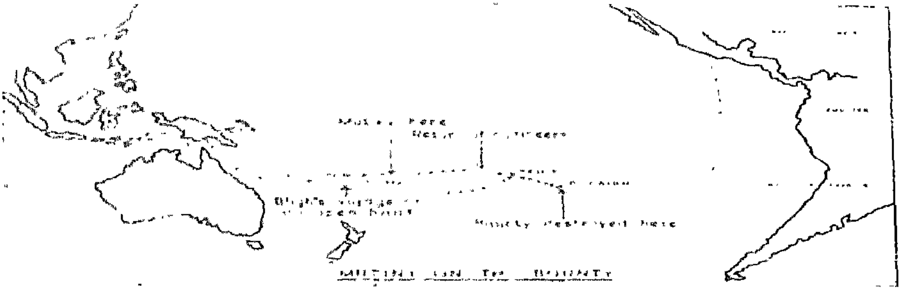


Fig. 2. Map to show part of the route followed by Bligh on his return journey from the Tahiti Islands. The mutineers left him in an open boat and returned to Tahiti. From there the Bounty was taken to the Pitcairn Islands and destroyed there.

However, now it has undergone a revival in the West Indies. Although not so popular as in the South Seas, it forms a basic part of the diet of the people of West Indies.

George Mackaness, biographer of Bligh, concludes that while at one moment he 'could abuse an officer roundly, in language hot and stinging', at the next, his anger cooling as rapidly as it boiled, he would invite the offender to supper with him. He never spared himself in the discharge of his duties, possessed unimpeachable integrity, and had a mind capable of providing its own resources in difficulties. His chief fault was an absence of tact and a failure to realise that wounds caused by the sword may heal but those caused by a sharp tongue are remembered for ever.

ESSENTIAL OILS

References to Sanskrit literature, including the *Ramayana* and *Mahabharata*, show that the distillation of essential oils and the preparation of perfumes was one of the most ancient crafts of India and in past she had the leading position in perfumery. In Mughal times the Emperor Babar (1483-1530 A.D.) was very fond of roses and we read in the *Ain-i-*

Akbari that he always encouraged the art of preparing perfumes and scented oils. The Empress Noor Jehan used to bathe in water scented with roses. For many years Indian perfumes were the rage in foreign lands. Queen Elizabeth (1533-1603 A.D.) as well as Mary, Queen of Scots (1542-1587 A.D.) extravagantly used Indian perfumes. At the French Court of Versailles, the King himself supervised the proper blending of essences for the royal bath, for which there was designed a different formula for each day of the year. In banquet halls it was not uncommon to have perfumed doves fluttering about so as to fill the room with aroma (Fig. 3), and slave girls used to comfort guests with scented fans. Nobles used to have the horses drawing their coaches annointed with perfumed oils so that the backward breeze brought an aroma to them.

In the 18th century the export of Indian perfumes to England went up to such an extent that the British Parliament took the matter rather seriously. Very likely quite a few of its members had discovered to their chagrin that the lovely creatures whom they had wedded were not all they had seemed, and every night each of them shed a good part of her beauty much as a caterpillar sheds its skin. The following Act passed by the Parliament in 1770 speaks for itself :

Fig. 3. Scene showing a royal banquet with perfumed doves fluttering in the hall Indian perfumes were exported in large quantities to Europe during the middle ages.

'That women of whatever age, rank, profession or degree, whether virgins, maids or widows that shall, form and after such act, impose upon, seduce and betray into matrimony any of his Majesty's subjects by the scent paints and other such artificial means shall incur the penalty of the law in force against witchcraft and like misdemeanours and that the marriage upon conviction shall stand null and void.

Luckily the law is not in force today. If it were, almost every woman of a big modern town would be in jail! And probably she should prefer to be in jail with cosmetics than be outside without them!

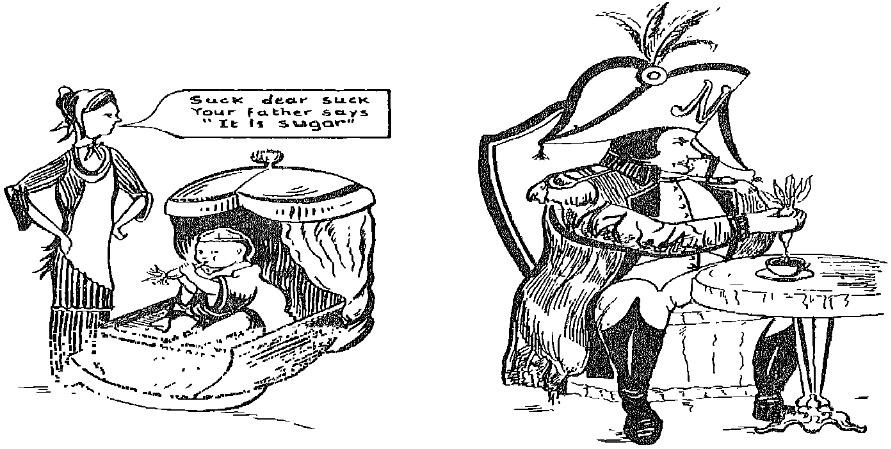
SUGARCANE AND SUGARBEET

It is generally agreed that South-east Asia, more especially India, is the original home of the sugarcane. According to Hindu mythology, Vishwamitra is said to have created the plant in the temporary paradise of King Trishanku, and it became available to the inhabitants of this earth only after the destruction of that paradise. According to some it is the bow of Kamadeva, the God of love. The word Ikshu occurs in the Atharva Veda (1,000 B.C.) and some royal families used the epithet 'Ikshwaku'. Alexander and his soldiers were perhaps the first Europeans to see sugarcane and wrote back to their friends in Greece that the barbarians across the Indus grew a reed from which they obtained all the honey they wanted. In the 5th century A.D. cane cultivation spread to Iran, and in the 7th century to Egypt and Spain. By the 16th century it had extended even to the New World which had been found by Columbus.

Now-a-days we take the selling and buying of sugar as an ordinary thing, but for centuries the only sweetening material known to Europeans was honey. When Indian sugar first became available to the West, it was a prized commodity. Nations contrived, struggled, plotted, and fought for trade supremacy in it.

In 1747 a German scientist, Marggraf, noted the presence of sugar in the roots of the beet but no serious notice was taken of this discovery except in Germany. During the days of Napoleon, the relations between England and France were strained for a long period. While Napoleon ruled the land the British Navy had command of the seas. The cessation of maritime trade had a paralysing effect upon the sugar refineries of Europe which had been importing raw sugar for many years and selling the finished product to Germany, France and other countries. Everywhere there was dearth of sugar. On March 25, 1811, Napoleon issued a decree subsidizing the establishment of the beet sugar industry. The beet was launched as a new crop in France. The British ridiculed the whole idea and published cartoons in their newspapers. One showed the great Napoleon sitting at coffee and squeezing a big beet root in his cup. In another (Fig. 4) a nurse had thrust the thin end of the root into the mouth of Napoleon's little son, the King of Rome, and was saying "Suce moncheri, suce, ton pere dit que c'est due sucre" (Suck, my dear, suck, your father says it is sugar).

The encouragement, which King Frederick of Germany and Napoleon gave to the beet, together with the work of selection and breeding undertaken by botanists, has made it one of the most important crops of modern times. A mediocre in productivity has been transformed into one of the greatest of our agricultural crops through the joint efforts of kings and scientists.



THE NURSE TO NAPOLEON'S SON, THE KING OF ROME SUCK DEAR SUCK. YOUR FATHER SAYS, "IT IS SUGAR"

THE GREAT NAPOLEON SQUEEZING A BEET ROOT TO SWEETEN HIS CUP OF COFFEE.

Fig. 4. Two old but famous cartoons showing how the British ridiculed Napoleon's idea of obtaining sugar from beet root.

THE OPIUM WAR

Opium was exported from India to China even in the 15th century, but this trade was responsible many years later for a war followed by serious consequences. After the sea-route to the East had been opened and the British had occupied parts of India, they tried to extend their influence to China. However, there was some difficulty about the ceremonial to be observed, and in 1793 the Chinese Emperor refused to see the British envoy. The ceremony to be performed was called the 'kotow', which is a kind of prostration on the ground. In reply to the British King's request for trade facilities, the Chinese emperor simply answered: "We possess all things and have no use for your country's manufactures."

However, the East India Company, ever ready for profits, continued to take a keen interest in exporting opium partly as a method of payment for silk and tea which they purchased from China. The Dutch in the East used to mix it with their tobacco and then smoke it as a preventive against malaria. The Chinese had gone one step further and used to smoke pure opium. The Chinese Government wanted to stop the habit because of its bad effect on the people, and also because the opium trade took away a lot of money from the country. However, it had little success.

In 1800 the Chinese Government issued an edict prohibiting all imports of opium. Unwilling to lose its profits, the East India Company persisted with the smuggling of opium into the country and bribed Chinese officials to overlook this. In 1834 matters became worse as the British Government put an end to the monopoly of the East India Company in the China trade, and threw it open to all British merchants.

There was a sudden increase in opium-smuggling, and the Chinese Government at last decided to take strong action. In 1839 they appointed one, Lin Tse-hsu, as special Commissioner to suppress the smuggling. He acted promptly. He went personally to Canton in the south, which was the chief centre for this illegal trade, and ordered the foreign merchants there to deliver to him their entire stock of opium. Since they refused to obey, Lin cut them off in their factories, made their Chinese workers and servants leave them, and allowed no food to go to them from outside. This vigour and thoroughness resulted in the seizure of 20,000 chests of opium. Lin destroyed all of them and told the foreign merchants that no ship would be allowed to bring opium to Canton. If this promise was broken, he threatened to confiscate the ship and its entire cargo. Lin played his part well, but did not foresee the effect of his policy.

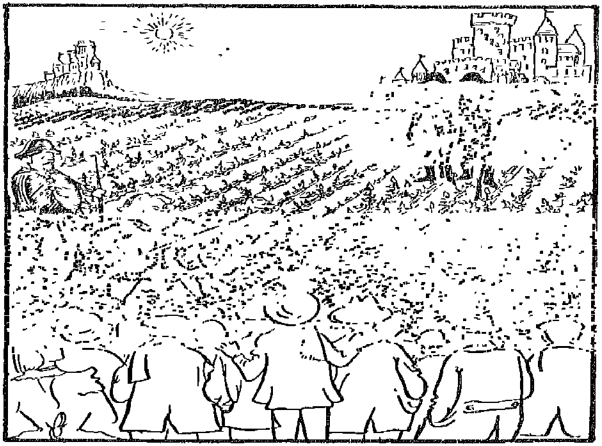
In the name of national honour and for the right of forcing opium on China, Britain declared war on the country in 1840. China could do little against the British fleet which blockaded Canton and other places. After two years she was forced to submit, and in 1842 the Treaty of Nanking laid down that five ports were to be opened to foreign trade which at that time meant especially the opium trade. These five ports were Canton, Shanghai, Amoy, Ningpo, and Foochow. They were called the 'Treaty Ports' in which British merchants had the right to 'reside and carry on trade'. Britain also took possession of the island of Hongkong, near

Canton and extorted a large sum of money as compensation for the opium that had been destroyed, and for the costs of the war which she had forced on China.

The Chinese Emperor made a personal appeal to Queen Victoria, pointing out with all courtesy the terrible effects of the opium trade which had been forced on China. There was no reply from the Queen. Only fifty years earlier his predecessor, Chien Lung, had refused to meet the British envoy.

POTATO

The potato is one of the most important food crops of the world. Believed to have originated in Peru and Bolivia, it was introduced into Spain in 1570 soon after the discovery of America. About 1586-1588 it was taken to Ireland by Sir Walter Raleigh. The French gave it the name 'pomme de terre' or apple of the earth. There was a lot of



POTATO FIELD NEAR PARIS, GUARDED BY SOLDIERS

Fig 5. When potato was introduced into France in the 18th century no one liked it A Frenchman, named Parmentier, planted a field near the King's palace. The field had a military guard in daytime to arouse the curiosity of the people as to the kind of food that was being grown for the King.

opposition in Europe to potato in the 16th and 17th centuries and most persons held it at an arm's length. Some said it caused leprosy; others said it gave rise to scrofula, rickets and tuberculosis. Still others denounced it on the ground that it was not mentioned in the Bible. The credit for promoting potato culture in Prussia goes to Frederick the Great. In 1744 he caused seed potatoes to be distributed free and compelled the peasants to cultivate them under threats of cutting off their noses and ears. The scarcity of food, caused by the Seven Years' War gave much encouragement to the industry. However, even as late as 1774 the hungry people of Prussia rejected a load sent by Frederick the Great: "The things have neither smell nor taste, not even the dogs will eat them, so what use are they to us?" England was not far behind in such nonsense

Fig. 6. In the night the guard was removed, and plenty of men and women went with picks and shovels to collect the potato tubers.

and one man standing for election to the Parliament used the slogan: 'No potatoes, no Popery'. Potato was regarded as the badge of servility, utterly unfit for free men and specially Englishmen. Many farmers fed potatoes even to pigs and horses with great reluctance lest they may poison the poor animals.

The introduction of potatoes into France was largely due to Antoine Auguste Parmentier who, while a prisoner in Germany during the Seven Years' War, was fed upon potatoes and had learned to like them. Parmentier planted them on a piece of land obtained from Louis XVI (1754-1793) This was at first a sandy waste but the potatoes turned it into a blooming garden. A military guard in full uniform was stationed near the field during the day (Fig. 5) but was withdrawn at night, whereupon a number of people came secretly to steal the tubers (Fig. 6). They ate them with relish and planted them in their own gardens—the very object which Parmentier had in view.

At one time, when his plants were in full bloom, Parmentier presented a bouquet of the flowers to the King who placed one in his buttonhole and gave the rest to his Queen, Marie Antoinette (1755-1793). She appeared in the evening wearing them in her hair. All the court tried to imitate their example. When Parmentier died, potatoes were planted on his grave. In England too it was the peers who first ate potatoes and the common people followed. Hot baked potatoes soon began to be hawked by vendors in London streets. It was, however, in Ireland that the potato was especially popular and became the staple food of the people.

In 1778 there was a war between Germany and Austria which is commonly known as the Potato War or 'Kartoffel Krieg'. Frederick the Great invaded Bohemia, and the Austrian army and his own faced each other on the Elbe near Koniggratz. Partly because of shortage of supplies and partly because of the strength of the Austrian position, Frederick realized that the campaign, as he had conceived it, was not likely to succeed. 'Both the Prussian and the Austrian armies thenceforth confined themselves to the 'potato-war'—that is, they consumed the resources of the enemy's country, till the cold weather set in and forced them to terminate their inglorious campaign by evacuating Bohemia' (*Cambridge Modern History*, vol. 6 : 706, 1909).

In Cromwell's campaign against Ireland, the potato played a different part. After subduing the chief urban centres, the invader wanted to punish and overawe the peasants by sending harassing bands to villages. Here the potato proved a source of great strength to the Irish, for the underground crop still remained intact when overland crops were open to destruction and loot by the soldiers.

BLIGHTS, RUSTS AND MILDEWS

As already mentioned, the potato enjoyed special popularity and became the staple food of the Irish people. However, this dependence on [illegible] trouble and suffering. There was a [illegible] 1845 and again in 1846. Father Mathew [illegible] the 27th of the last month (July 1846) I passed from Cork to Dublin, and this doomed plant bloomed in all the luxuriance of an abundant harvest. Returning on the third instant (August) I beheld with sorrow one wide waste of petrifying vegetation. In many places the wretched people were seated on the fences of their decaying gardens, wringing their hands, and wailing bitterly the destruction that had left them foodless.

Nobody knew the real reason for the failure of the crop. Many believed it to be a scourge from God to punish the sins of the people. One writer said that the trouble was due to volcanic action within the earth. Other blamed the weather. Lindley, the editor of the *Gardener's Chronicle* of London, who examined the infected leaves under the microscope, considered the fungus to be an excrescence from diseased tissue and not the cause of it. The price of ignorance was terrible. "With startling rapidity, shortage passed to famine, famine to starvation, and starvation to death, which, if it brought peace to its elect, augmented the suffering of those it spared." (Salaman, 1949).

In their helplessness many of the Irish people emigrated to the United States. As Salaman says in his book on the *Origin of the Potato* the emigrants carried with them 'into their new life overseas an inverted love of their old home, in the form of a deep anger and a bitter hatred of England, to whom they ascribed not only the old historic grievances, but the cruel misfortunes which had overtaken them in consequence of the potato famine'.

To mention another example, at one time coffee cultivation was to Ceylon what maize is to North U.S.A. or wheat is to the Punjab. The little island had taken to this crop with great enthusiasm and was making good profits through it. In 1869 M. J. Berkeley described a pretty microscopic fungus on some coffee leaves received from the Botanical Gardens at Peradeniya and named it *Hemileia*. At that time neither the planters nor the Ceylon Government bothered, but within the next 10 years the disease spread over the whole island. The fungus did not kill the host outright but there was a frequent shedding of the leaves so that the productive capacity of the plants was reduced to less than half. The Ceylon Government now woke up and wrote to England for help. In 1880 the authorities at Kew recommended to them the services of H. Marshall Ward. He made a thorough study both in the field and the laboratory but it was already too late to save the coffee. The productivity of the trees continued to go down. It was a losing battle and coffee cultivation no longer remained profitable. Ruined and discouraged, the planters turned to quinine, rubber, cocoa and finally to tea. The centre of coffee production shifted to Brazil where sometimes there was so much overproduction that the coffee berries were burned to keep up the prices.

The cloves, that we use in cookery and to sweeten the breath, are the dried flowerbuds of a tree known as *Syzygium aromaticum* belonging to the guava family. Shredded cloves are often mixed with tobacco to make scented cigarettes, and the oil is used to make vanillin, a substitute for pure vanilla. Formerly most of the cloves of the world came from the Molucca Islands and the Dutch held a monopoly for many years. Later, the plants were grown in Mauritius. One of the Sultans of Zanzibar introduced it into his kingdom and the adjacent Pemba. It is these two islands which now supply 80 per cent of the cloves of the world and for many years they have lived largely on the export of this fragrant commodity. During recent years the clove industry of Zanzibar has faced grave peril because of the so-called 'sudden death' disease.

Then consider the cocoa industry of Ghana. The first fruit of *Theobroma cacao* was imported into the country and the owner could sell each pod for more than two dollars. Later the industry began to grow. During the five years from 1892 to 1896 the total production was only 12 tons, but in 1951 it had already climbed to 2,75,000 tons. During the last ten years the crop became afflicted by a disease called 'swollen shoot', which is caused by a virus and spread by an insect known as mealy bug. The eastern part was the worst affected and it was believed that the disease came from Togoland in 1930. It was feared that the cocoa industry of Ghana might have the same fate as the coffee industry of Ceylon. When orders were given to the farmers a few years ago to destroy the infected trees and burn them, they at first refused to do so. However, the government acted with vigour and firmness. The disease subsided and once again cocoa has had some big booms.

THE INDIGO SATYAGRAHA

Dyes have long been used to (1) ward off evil spirits ; (2) to frighten enemies ; and (3) to make oneself more attractive. The world would be a drab affair without the multicoloured dresses of women and the neckties of men. Krishna and Baldev were called 'nilambara' and 'pitambara' because of the blue and yellow dresses they wore. In the *Mahabharata* we read about Prince Uttara removing the coloured dresses of the Kauravas after they had been rendered senseless by Arjuna. The mummies in Egyptian tombs have been found clad in clothes coloured with indigo, madder and saffron. In the Bible there is a reference to the coloured dress of Joseph and how his brother envied him because of it.

Indigo was the king of all ancient dyes and was being grown in India from times immemorial. The dye was greatly in demand by the Greeks and Romans After the Roman empire broke up, indigo as a colouring matter was lost to Europe for centuries But the Dutch re-introduced it in the middle of the 16th century and Bengal became the chief centre of the indigo industry In 1631, on a single day, three Dutch ships took some 333,000 lb of indigo from India to Holland. None of the Europeans had any knowledge of the source of the dye and even till 1705 they thought that it came from mines.

When the British occupied India, they found the crop so profitable that some of them established themselves as landlords in order to carry on the trade in indigo They exacted from their tenants many kinds of fines and 'begar' (forced labour), and levied a tax on every marriage, hearth and oil mill. If the sahib needed an elephant or wished to pay a visit to the hills, the tenants had to bear the cost. The peasants had to grow indigo on a fixed proportion of the land they rented and this was never less than 3/20 of its area (the so-called *tin-kathiya* system) The planters also fixed their own price for the crop. When labour was hired, the wages were on starvation level—10 pice for a man, 6 pice for a woman and 3 pice for a child, working nearly 11 or 12 hours per day.

The tenants found conditions so difficult that sometimes they refused to fulfil them. However, the British Government, which was more interested in the landlords than the tenants, passed special laws to terrorise the latter. Any cultivator, who was audacious enough to defy the planters, was harrased and subjected to all kinds of cruelties. His house would be looted, crops destroyed and stray cattle let loose on his lands He would be dragged into false cases, made to pay fines or even beaten up. Sometimes, in sheer despair, the cultivators revolted and killed a planter or two. However, they were no match for the organised strength of the planters with the British Government behind them. Repression would be let loose and every revolt only worsened the peasants' condition. The late Dinabandhu Mitra wrote at that time a Bengali drama known as *Nildarpan* depicting the inhuman oppressions to which the cultivators were subjected. The man who translated the drama into English lost his job ; the planters denounced it as grossly obscene and libellous, and the printer, Rev. J Long, an English clergyman, was promptly prosecuted. He was sentenced to pay a fine of Rs. 1,000 and to serve one month's imprisonment. The fine was paid then and there by one Kali Prasad Sinha, a citizen of Calcutta.

Meanwhile Perkin (1856) synthesized indigo in England and the dye industry was developed to such an extent by German chemists that indigo plantations became unprofitable The planters now adopted the expedient of freeing their tenants from the obligation to grow indigo but charged them an enhanced rent or gave the land in return for the payment of a good sum in cash

In 1914 World War I broke out in Europe and the import of foreign dyes stopped. The prospects for indigo brightened, and the planters again began forcing the tenants to grow indigo. Partly due to this and partly due to the damage caused to their economy by the war, their condition became more and desperate, and the situation was brought to the notice of Mahatma Gandhi (1869-1948) soon after he returned from Africa to India The Lucknow session of the Indian National Congress adopted, in 1916, a resolution of sympathy with the peasants on the indigo plantations at Champaran at the foot of Bihar Himalayas. A villager, who attended the congress, went after Gandhiji from place to place and succeeded in bringing him to Champaran for an inquiry that made a turning point in Gandhiji's career (Fig. 7). Gandhiji agreed to conduct the inquiry with the late Dr. Rajendra Prasad (Later President of the Indian Republic) and Mahadev Desai as his helpers and assistants. The Commissioner served him a formal notice under the notorious Section 144 of the Indian Penal Code, requiring him to leave Champaran. Gandhiji refused to comply and was put on trial. He read a statement in the court saying that his presence could not possibly disturb the public peace and that his sense of duty bade him remain where he was. This respectful but firm defiance took the magistrate by surprise. The Lieutenant Governor, Sir Edward Gait, ordered the case to be withdrawn, and made Gandhiji a member of an official inquiry committee. This committee stood up for the peasants. The planters had to repay one-fourth of their unlawful exactions, the *tin-kathia* system was declared illegal, and land revenue was reduced. This was Gandhiji's first act of civil disobedience on Indian soil and he immediately became a national hero. The Champaran struggle was a sort of small scale rehearsal in the technique of Satyagraha. Bigger things were to follow.

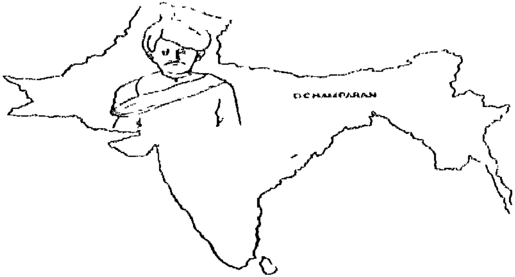


Fig. 7 The indigo trade had such an diverse effect on the life of the peasants of Bihar, that Mahatma Gandhi started his first Satyagraha movement at Champaran in 1917.

COTTON, NEGRO SLAVERY, ENGLAND, AND INDIA

Among the most interesting discoveries in the excavations at Mohenjodaro (Now in West Pakistan) (3,000 B.C. ?) were some pieces of silver wrapped in a fabric which was found to be cotton, the counts of yarns and the structure of the cloth indicating the attainment of a high degree of skill in the arts of spinning and weaving even in those distant times. This achievement may well be considered as more noteworthy than that of the Egyptians who were using the much longer stem fibres of flax.

Herodotus, the Greek historian and traveller, wrote in 445 B.C. that, 'there are trees growing in India, the fruit of which has a wool exceeding in beauty and goodness the wool of sheep'. Some writers concocted tales of a lamb sitting inside the fruit. The Greeks learnt of the cotton plant through the group of explorers who accompanied Alexander the Great and his immediate successors. From that time onwards the cultivation of cotton, its use for the manufacture of various fabrics, and their dyeing and finishing progressed steadily until in the Middle Ages the fame of India's cotton materials spread far and wide and she had a roaring trade in them not only with the adjoining countries but also with far distant lands through Venice. Marco Polo mentioned the Coromandel coast as producing 'the finest and most beautiful cottons in the world'. The softness, fineness and beauty of the Dacca muslins is legendary. It is said that when such muslin was laid on grass to bleach and the dew had fallen, it was virtually transparent. A whole garment could be drawn through a ring. There is also the oft repeated story of a Moghul princess who was putting on seven layers of muslin and still the contours of her body were so visible that she had to be admonished by her father.

Those glorious days were followed by a period of decline during which India's textile industry was discriminated against by the East India Company and later by the British Government. The revival came only in comparatively recent years.

India was, however, not the only country which grew cotton in the past. In the New World also cotton fabrics have been found in ancient Peruvian tombs. The Spanish discoverers of the Americas found cotton in the region from the West Indies to Mexico, Brazil and Peru, and in some of these countries the art of making cloth was highly developed.

The introduction of cotton into the south eastern area of the U.S.A. came much later. In 1621 some seeds were planted as an experiment and a coarse cloth was manufactured on a small scale towards the end of the century. In another hundred years this textile furnished most of clothing of the poorer classes in the southern states. In 1747 some cotton was exported from America to England. In 1794 came Whitney's invention of the cotton gin which gave a tremendous impetus to the cotton industry. Henceforth, cotton became an important crop in the U.S.A

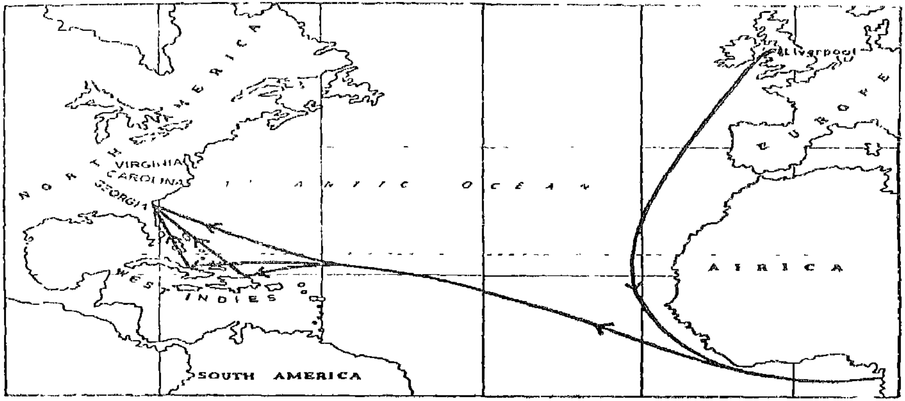


Fig. 8 Route taken by the slave ships in the 16th and 17th centuries The ships left Liverpool and touched the West Coast of Africa After that they sailed west with their cargo of slaves, who were sold in the Caribbean Islands and south-eastern states of the U.S A., to help in the cultivation of cotton and sugarcane.

It is to this extension of cotton cultivation in the U.S.A., that the negro problem of America must be traced. In the cotton growing areas the summer temperatures are rather high and there was an obvious need for cheap labour was necessary to bring more profits. The American Indians were a rather independent type of people who refused to co-operate with their white conquerers. Since a good proportion of the cotton for the Lancashire mills went from the southern states of the U.S A., British ships found it a profitable business to capture negroes from the West African coast and sell them in America for work on the cotton fields (Fig. 8). To economise space and transport of the largest number of negroes, the ships were specially made with galleries between decks. In these the unhappy negroes were made to lie down, all chained up lest they may try to escape by jumping into the ocean. The space allowed to each was five and a half feet long by sixteen inches wide. Later they also captured negro women and the State of Virginia made special efforts to breed negroes, for this was cheaper than carrying them across the ocean. Towards the end of the 18th and the beginning of the 19th century as many as 100,000 slaves were carried every year from the African slave coast. Having discharged their human cargoes, merchants loaded their ships with tobacco, sugar, rum and molasses and returned to England.

Differences arose about 1830 between the North and the South with regard to the slave trade and the legality of slavery. Apart from slavery their economic interests were also different. In 1860 Abraham Lincoln (1802-1865) was elected President of the U.S A. He was opposed to slavery and his election was a signal for the South to break away from the North. He tried to bring about a compromise but failed Eleven states of the South broke away from the North. Lincoln refused to recognise the right of any State to withdraw from the Union and a Civil War followed in 1861 All the early victories went to the South, but the North had much greater resources and in 1865 the South had to accept defeat. The negroes were made legally free and although incidents still occur sometimes, generally their condition is reasonably satisfactory and no worse than that of many untouchables in this country.

In the Old World the import of cotton cloth from England into India was one of the principal reasons for the strained relations between the two countries. England took raw cotton from this country and sold the finished product to India. Lancashire grew fat, while the Indian peasant became poorer and poorer. Gandhiji, with the spinning wheel, emerged as a world figure, and the boycott of British cloth made the occupation of India unprofitable.

The Europeans came to India because of its rich plant resources, particularly spices. When spices were no longer so important, it was still profitable to retain India as a market for British goods. Once India refused to buy them, it no longer remained the gold mine it was. Gandhiji's method was simple but sure, and India gained its independence in 1947.

RECENT TIMES

In recent times everyone will remember that the chief reason for military agression by Germany was not so much the *Lebensraum* or living space, which Hitler spoke of, but a consuming desire to occupy the wheat fields of the Ukraine and certain other areas to obtain more food for his crowded population. A major reason for Japan's Blitzkrieg against Sumatra, Java and Malaya was her desire to close these, the world's most important rubber-producing areas, to the western powers and thus stop their supplies of a strategic material in war. Along with rubber, also went cinchona which was needed for the manufacture of quinine. This too was an important commodity for soldiers fighting in malarial areas.

CONCLUSION

In ancient times wars were fought for women. Sita, Helen, Padmini and Samyukta are well-known examples. Later they were fought for the spread of religious faiths. In the sixteenth and seventeenth centuries gold, spices and perfumes made history. Present day wars are not fought for women, or religion, or even gold, but for cereals, rubber, petrol (a plant-animal product), coal, iron ore, beryllium, thorium, etc. Who knows that in future also the desire of countries and nations to control plant and mineral resources may lead to major events in the history of the human race ? Indeed, plant power is world power.

BIOCHEMISTRY IN THE SERVICE OF MANKIND

P. S SARMA

Indian Institute of Science, Bangalore

Biochemistry, which may be defined as the chemistry of life processes, though relatively a new branch of science, has assumed considerable importance in recent years. There are several reasons for this phenomenal development of this branch of science. Hundreds, if not thousands of scientists, throughout the different parts of the world have been engaged in the study of biochemistry of microorganisms, plants or animals. Biochemists have developed new tools for research, particularly by use of radioactive isotopes, and have studied a great deal about life processes both at the molecular level and at the level of organisation of different kinds of cells. The award of Nobel Prize in chemistry and in medicine to biochemists in recent times is a further indication of the enormous developments, which have taken place in this field of science and the tremendous impact of these developments on human welfare in general. It will be an impossible task to give in any detail, the innumerable ways in which this branch of science has been of immense service to mankind. I shall, therefore, endeavour to illustrate with a few examples based on personal experience and on the experience of my colleagues' research work in the Biochemistry department of our Institute, the tremendous impact of this branch of chemistry on human welfare.

DNA and RNA

It has been known that hereditary characters are passed on by thread-like structures called chromosomes. In multicellular organisms nearly every cell has an identical, complete set of chromosomes usually located in the cell nucleus. Chromosomes are themselves made up of smaller units called genes, strung out along the chromosome like beads on a string. Each gene is responsible for a distinct hereditary characteristic. A single chromosome may contain thousands of genes. The genes are too small to be seen even with the aid of a microscope.

A geneticist, Morgan, had discovered that cells in the salivary glands of the fruit-fly larva contain chromosomes of great size. When suitably stained, they can be seen under an ordinary microscope. Geneticists observed on them light and dark bands. These bands had been identified as giant genes. But, no one knew what genes were, physically and chemically, and how they functioned. These questions could not be answered so long as the experimental material was the insect.

In 1941, Beadle and Tatum carried out experiments with the common bread mould called *Neurospora*, which could be cultivated in a simple medium. They proceeded to knock out one or more of the genes by exposing cultures of this organism to X-rays and to study the behaviour of the organism. They showed that genes control cell chemistry and that there is a growing gene for every chemical reaction taking place in the living cell

The work of Beadle and Tatum—they were awarded Nobel Prize—established the essential nature of what genes do, but not what they are. This was finally revealed by studies on another microorganism—*Pneumococcus*, which is responsible for bacterial pneumonia. Colonies of this organism growing in a culture dish ordinarily look smooth and glistening to the naked eye. This is due to the organism's waxy outer coat. Occasionally, however, colonies of *Pneumococcus* without the waxy coat are found. These appear to have rough surface. Great interest was taken in the coatless pneumococci when it was discovered that they were non-virulent, i.e. unable to cause pneumonia.

When the virulent, coated organisms were killed, using heat, and were placed in a culture dish along with the non-virulent, uncoated ones, surprisingly the uncoated organisms regained their coats and became virulent again. It was strange, that the dead microbes altered the live ones. The puzzle was cleared up by the work of Avery, Macleod and McCarty at the Rockefeller Institute in New York. They showed that gene material passed from the dead to the living organism. When extracted and purified, the gene material proved to be a compound known as deoxyribonucleic acid or DNA.

Later work has shown that cells contain in addition to DNA, a compound called RNA (ribonucleic acid). RNA and DNA resemble each other closely ; chief differences are in some of the building blocks from which they are formed. During the last ten years our knowledge of this genetic material has considerably improved. In 1959 Kornberg was awarded the Nobel Prize for medicine for his discovery of the enzyme responsible for the synthesis of DNA. Last December, Crick, Wilkins and Watson were awarded the Nobel Prize for the discovery of the molecular structure of DNA and establishment of the 'biological code' for the formation of enzymes. This work is now exerting a profound influence on biochemical and biological research, especially in the fields of molecular biology and heredity.

Medical specialists believe that this new knowledge of the chemistry of genetic material is likely to be useful in the study of the cancer problem.

Vitamins

Although modern biochemistry has much to do with the investigation of the chemical changes that take place in cells and organs of the body and in extracts and preparations made from such tissues, there is a branch of enquiry important to biochemistry, no less than to physiology, in which the living animal must be employed. This is the study of nutrition in its general aspects. Hopkins, half a century ago, working under circumstances at which the average student today would turn up his nose, discovered the stimulatory effects of minute amounts of certain substances on the growth rates of animals fed on specially prepared diets. These substances he called necessary food factors but we know them now as vitamins. Such substances are now available in highly concentrated or pure form. Many of them, through the brilliant work of the organic chemist, have been synthesised and they are on the market for all to consume at competitive prices. Every child today knows about vitamins. During the war, in England children were given free fruit preparations to ensure a sufficiency of vitamin C. The balanced diets that form an important feature of rationing schemes in times of war, are so arranged that vitamins are well represented and in proper proportions.

Are we sure of the entire therapeutic value of the vitamins ? Have they wider application than in conditions which are clearly recognised as deficiency diseases and which fortunately, today, in view of our advanced nutritional knowledge, are relatively rare ? Clinicians are apt to reserve judgment here, but there is a conviction that nutritional deficiencies play a larger part in the causation of disease, or in the failure to resist disease, than has hitherto been considered possible. Vitamin-therapy has a very important future. Moreover, we do not know what further vitamins there may be to add to our growing list. The story of the cautious grocer may be recalled in this connection, who in advertising a new food product to the public stated that it contained all known and unknown vitamins. Such combined caution and optimism surely indicated good business ability.

The biochemist, however, is anything but content with knowing what vitamins are ; he wishes to know what they do. They are effective in such small amounts that their biological activities in controlling chemical events in the living cell are enormous. Great advances have been made in recent years in our knowledge of the mechanisms of action of some vitamins but the position is far from being satisfactory. We have learned something of the mode of action of pantotheinic acid, nicotinic acid, pyridoxin, substances belonging to what is called the vitamin B group, but we have practically very little knowledge of the manner in which vitamins A, C, D and others play their roles in supporting normal health.

Control of Disease Processes

The task of biochemistry is to explore all the mechanisms taking part in the living cell, to discover the inter-relationship of all the chemical changes that result in the life of the cell and to describe in objective chemical terms how such substances as nutrients, vitamins and hormones intrude into the chemical events of metabolism. Such processes embrace all the building up and breaking down that goes on in the cell. The great majority of processes involved in metabolism are catalysed or controlled by enzymes. The enzymes are organic substances of complex structures; they are proteins that can be separated from the living cell and examined in states of great purity. Many of them can be crystallized. They are biological catalysts of great activity and specificity of action. It will illustrate the efficiency of biological catalysis in general if it is remembered that an enzyme preparation may change in one second at room temperature anything from 10 to 1000 times its weight of the substance with which it is in contact, and to which it is specifically adjusted. Innumerable quantitative studies have been made of enzymes and their action, of the velocities of the reactions that they catalyse, of their varying affinities and associations and of the range of their influence. Such studies give us the information that enables us to control their activities.

The advance of years has made it abundantly clear that in the very many ills that affect mankind, studies of the chemistry of the body and of the underlying enzyme activities are playing an increasingly important role, both for an understanding of the underlying causes and for, what is more important perhaps to most of us, their successful treatment.

Many aspects of medical service, whether they deal with diseases due to nutritional deficiencies or to hormone defects or to congenital disturbances, or with diseases due to impaired sugar, fat or protein metabolism or with diseases due to the invasion of microorganisms, or with the bodily manifestations resulting from lack of oxygen, or the investigation of poisons—all these are inevitably linked with biochemical phenomena whose study is essential for their understanding and control. Enzyme activities are at the basis of all these phenomena and it is for this reason that enzymology—the study of enzymes in all their aspects—is playing an increasingly important part in modern medicine.

One or two examples may be considered of how fundamental studies of enzymes have enabled us to approach certain disease problems and to formulate a rational way of seeking new drugs.

Although enzymes exhibit an extraordinary specificity of action, it was realised over 30 years ago that they may have a high affinity for a large number of substances, only one or two of which, by reason of their special chemical and physical characteristics, are able to break down and thus enter the chemical activities of living cell These substances that have a high affinity for the enzyme but which are not broken down, can compete with the substances that are broken down if they happen to be mixed together. The effect of such admixture is, therefore, to diminish the activity of the enzyme towards its substrate. The mere addition to the nutrients of living cell of a substance closely related in chemical structure to one of the nutrients will have the effect of the starving the cell of that nutrient. This is simply because the added substance combines with the enzyme attacking the nutrient. It drives this off and inserts itself in its place. Since the added substance by itself has no nutrient value, as it is not broken down, it acts as a poison to the cell, preventing the enzyme with which it combines attacking the needed nutrient. It, therefore, prevents the cell from obtaining the energy, or new cell constituent, that it requires for its normal healthy activity A process of selective or specific starvation of the living cell of a particular food that it needs thus takes place.

This principle of competitive inhibition of enzymes, by what are called nowadays the chemical or structural analogues of cell nutrients, was known about 35 years ago. Yet its practical significance was not realised until after several years. At that time it was known that a drug called sulphanilamide would prevent certain highly infectious microorganisms such as *Streptococci* from growing in the human and animal body. But the mode of its action was not known. It was then found that a certain substance called pamino benzonic acid or PAB for short, would neutralise its action and it was realised that the sulphanilamide was working because it was a structural analogue of the substance PAB. It was in fact effective as a bacterial inhibitor, because it combined with an enzyme which converted a nutrient, PAB, into an important cell constituent necessary for the life of the microbes. The sulphanilamide acted as a competitive inhibitor and starved, by reasons of its closeness of chemical structure to PAB, the microbe of the PAB it needed.

This discovery made chemists immediately aware of the significance of the principle of competitive inhibition in the treatment of disease. A huge series of sulpha drugs was made and tested for bacterial inhibitive power, and some of the more effective of these have been on the market and have been of great medical value.

Several years elapsed before the practical significance of the principle of competitive inhibition in the field of medicine was made apparent. This delay in appreciation is by no means unusual in biological science. The role of the pancreas in diabetes was realised in 1889 ; yet it was not until 1922 that insulin , extracted from pancreas, was used for the treatment of diabetes. Pencillin was detected first in 1929, but it was not until after

1940 that it was used as antibiotic. It is quite likely that facts of major importance are being described today whose practical significance will not be appreciated for years to come.

Within the last few years the potent antibiotics, mostly products of the life processes of fungi, have sprung unexpectedly among us. They represent substances whose mechanism of action still, for the most part, eludes us. It is the task of the biochemist to discover how they work, to find out whether more powerful and specific drugs can be modelled upon them, and whether they give the clue to the nature of as yet unknown chemical processes in the susceptible cells.

Two antibiotics, morellin and guttiferin, present in the Mysore Gamboge tree have been isolated and shown to be inhibitory to many bacteria. Morellin has been used successfully for treating septic wounds, boils and ulcers in hospitals. A new species of *Streptomyces* isolated from the soil has been found to produce substances detrimental to many moulds and fungi, including those that cause skin diseases

Agriculture

Apart from the obvious importance of biochemical knowledge and advances in the nutrition of livestock and dairy animals, and the wealth of data that is now accumulating on the effects of feed supplements such as the vitamins, or hormones and even antibiotics, on the growth of animals, there is now a lively appreciation of the importance of plant physiology and biochemistry in agricultural practice. It is not so long ago that the principle of replacing artificially the substances removed from the soil by crops was given a scientific foundation and is now followed by every progressive farmer. The need of a plant, for its normal nutrition, of nitrogen (in the form of nitrates or ammonia) or of phosphate of potassium is so well recognised that every farmer applies his NPK fertilisers as a matter of routine Perhaps the story may be told of the farmer who had worked for years on a land that looked rich but lacked potassium. He came to see a demonstration of the effects of potassium on a crop of corn at the Illinois Agricultural Experimental Station and brought with him his wife and children.

'As he stood looking first on the corn on the treated and untreated land, then at his wife and children, he broke down and wept. Later he explained to the superintendent who was showing him the experiments that he had put the best of his life into that kind of land'. 'The land looked rich' he said, 'as rich as any land I ever saw. I bought it and drained it and built my house on a sandy knoll. The first crops were fairly good and we hoped for better crops, but instead they grew worse and worse. We raised what we could on a small patch of sandy land and kept trying to find out what we could grow on this blank bogus land. Sometimes I helped the neighbours and got a little money, but my wife and I and my older children have wasted twenty years on this land. Poverty, poverty always. How was I to know that this simple substance which you call potassium was all we needed to make this land productive and valuable ?'

Deficiency diseases of plants, i.e. diseases due to lack in the soil of various mineral elements needed by plants for their optimal growth and nutrition are now well recognised and the methods of treatment are known. The so-called trace elements, manganese, boron, molybdenum, only so called because the plants need little of them--but yet that little is so vital for healthy growth of crops —are known today to be as indispensable as the familiar NPK for the maintenance of soil fertility. The mechanisms of action of some of these substances in the plant cell are now being understood. What is equally important is that we are now beginning to understand how these substances undergo a biochemical change in the soil itself by the microorganisms there, and that much depends on the chemical events in the soil, whether the manganese or iron, for example, are in the proper form in the soil for absorption by the plant roots.

The soil must be recognised as a vast living system, whose biochemical study is of as great a practical importance to man as the study of the animals and plants

Industry

Biochemistry finds applications in industry also, such as fermentation and dairy industries. In the Institute here, improved strains of yeast have been produced, in which their chromosomes were doubled artificially. Some of the mutant yeast are of practical importance in the fermentation industry.

During World War II, a considerable amount of industrial work was undertaken in the Institute, e g., the preparation of calcium gluconate, different gland products, animal rennet and commercial pancreation. A suitable method was developed for the treatment of the enormous quantity of the industrial waste and wastes from about eighty textile mills at Ahmedabad. Other industrial waste, such as those from spinning mills and tanneries, were also studied on behalf of the industries.

At the moment work is in progress on the treatment and utilization of waste water for use in the manufacturing processes in the textile industry. The work has been undertaken at the request of the authorities of a local textile mill, who are confronted with the problem of growing shortage of suitable water for their industrial operations. The available waste water contains suspended impurities like mud, coal dust, oil and different forms of organic matter, including readily putrescible matter, and it emits a foul odour. The pilot plant experiments carried out at the mill premises, have indicated the possibility of reclaiming water of satisfactory quality—satisfactory from the chemical as well as the bacteriological points of view—for the manufacturing processes in the textile industry.

Sanitation

The work carried out in the Department of Biochemistry on the composition of different waste materials developed into a nation-wide programme.

The studies on the principles of sewage treatment by various methods, including those of the newly observed process of natural purification of flowing on the outskirts of Bangalore City, and on the oxidation of other forms of organic matter as in aquaria waters, ponds, pools and waterlogged soils, have shown that protozoan activity in these systems—the activity of Vorticellids in particular—constitutes a basic principle of purification of environmental sanitation. The bearing of this observation on effective treatment and utilization or disposal of industrial wastes has also been examined.

Fairly extensive work has been done in the Department on the utilization of sewage and sludges for crop production. Their utilization in fisheries and poultry ration is being studied. Activated sludge is fairly rich in protein and it contains an appreciable amount of vitamin B_{12}.

Other Aspects

The broad field of biochemistry can also be divided for purposes of further illustration into carbohydrates, fats, proteins, nucleic acids, trace elements, vitamins, antibiotics, etc. Carbohydrates serve as sources of energy, and the biochemist tries not only to find new sources of carbohydrates, but also study its metabolic aspects. The several steps in the photosynthetic production of carbohydrates in plants has been studied with the use of radioactive carbon. Calvin, a Nobel Prize recipient has elucidated the various steps and with the synthetic production of chlorophyll, the green colouring matter of plants, the day is not far off when carbohydrates can be produced on a large scale for the benefit of mankind. *Neera*, the juice from palm trees has a special significance from the point of view of producing more carbohydrates for human consumption in the form of good quality jaggery and sugar. Preservation of *neera* with the antimalarial drug paludrine helps in its preservation and prevention of destruction from microorganisms. Though the present practice is to add lime as a preservative, the day is not far off, when paludrine can safely be used as a preservative and a large quantity of sugar made available for human consumption.

Fats and oils are also sources of energy and of late several non-edible seeds have been studied for their fat content with a view to seeing whether such fats can be made available for human consumption. The Vanaspati Industry relied in the past on edible oils such as ground nut oil, coconut oil and the like, but to day, oil from cotton seed is mixed with groundnut oil to produce hydrogenated fats. Further in recent years, the composition of the hydrogenated fats has been found to have a good deal to do with the raising of serum cholesterol in the human. The Vanaspati Industry gave us a grant of Rs 50,0 0/- to carry out experiments on monkeys to find out which of the vegetable oils, when added when fluorine is present in large amounts, as in the drinking water in areas around Guntakal in Andhra Pradesh, people suffer from mottled enamel teeth and certain bone deformities are produced in the human as well as in cattle population. Research work carried in the department has shown that excess fluorine can be removed from drinking water by activated paddy husk charcoal and thereby rendered safe for drinking.

A deficiency of iodine can cause in man the disease known as goitre and can arise either from the poor iodine content of the soil as in the Kangra Valley in the north of India or by taking certain goitrogenic agents in food. The one most commonly taken in some parts of India are the whole ground-nut, whose red skin coat contains substances which have the ability to combine with iodine and prevent the formation of the hormone thyroxine causing thereby the disease goitre. Prevention of goitre can be effected by adding potassium iodide to common salt—iodised salt—so that there will always be excess of iodine in the diet to help in the production of this vital hormone.

Biochemistry plays a major role in the study of vitamin deficiencies in man. Work carried out in our department has shown that it is not enough if those suffering from vitamin A deficiency take merely plenty of the vitamain A. Portein supplementation of the diet is equally important since without adequate protein, vitamin/A is not properly utilised.

Biochemical methods are also employed to study the status of vitamin nutrition in man. The vitamin C status in man can be studied by determining this vitamin content in the blood and in the urine. If there is a deficiency of vitamin C the levels of this vitamin are very low, in both blood and urine. Similarly if there is a deficiency of another vitamin of the B complex, pyridoxine, the urine will contain an abnormal excretory product, xanthurinic acid, which turns deep green to hydrogenated fats kept the serum cholesterol concentration at a uniformly low level. We have found in studies with the monkey that the addition of safflower oil and of sesame oil to such an extent to hydrogenated fat as to keep the level of saturated to unsaturated fatty acids within a certain ratio, greatly helped to keep down the serum cholesterol level for a period of six months

At present there is considerable research work carried out on protein malnutrition. A large number of children in undeveloped and underdeveloped areas of the world suffer from protein malnutrition. This is because the intake of good quality proteins is low and attempts are made to isolate good quality protiens as also an amino acid lysine, which when added to the rice diet or diet containing vegetable proteins raises their nutritional value Another aspect of study which has interested us is the toxic principles present in *Lathyrus sativus* of *khesari dal*, which is consumed in certain parts of Central India and which causes in the human neuromuscular disease called 'Lathyrism'. We have investigated this problem and have isolated new toxic principles from the seeds, which are like the amino acids of ordinary proteins but differ radically in structure and which consequently may cause the disease lathyrism when the seeds are consumed by man.

Biochemical studies of trace elements like fluorine and iodine have given us important results, which can be applied with benefit to the welfare of mankind. It is known that fluorine in small amounts prevents dental caries in children caused by taking too many sweets and chocolates. In fact in some cities in the west, fluorine in the form of fluoride is compulsorily added to drinking water to protect children's teeth from the onset of dental caries. However, on treatment with iron salts, this gives a very sensitive biochemical test for the detection of the vitamin deficiency Again it has been known from biochemical studies that if a person takes raw eggs in large quantities, the substance 'avidin' in raw egg white can combine with an important vitamin of the B-complex 'biotin' and make this vitamin unavailable to the human. The fortification of foods, particularly of wheat flour in U.S.A. with B_1, riboflavin, nicotinic acid, calcium and iron, which is compelled by law could not have been possible without the extensive research work carried out in the field of biochemistry

Concluding Remarks

Biochemistry is thus advancing rapidly. Its advances have been greatly influenced by the spectacular advances in physics. The advent of radioactive isotopes has made it possible to study aspects of biochemistry that were considered beyond the scope of investigation.

Biochemistry covers a very wide field, the study of all living things, either as single living cells or as organizations of living cells Its findings, and the conclusions based on them, affect all phases of human endeavour. Its influence is already felt, but we are only at the beginning As time goes on, its importance will increase and continue to contribute substantially to the health, prosperity and happiness of mankind

NUCLEAR REACTORS—WHAT ARE THEY ?

PART II—DESCRIPTION OF SOME REACTORS

L. S. KOTHARI

University of Delhi

In the previous article (*School Science* 2 : 12-18) it was discussed in a qualitative way how a self-sustained fission chain-reaction can be established, and also the various types of basically different reactors that are possible. Almost all these different reactor concepts have been tried experimentally. It is impossible to describe them all in a short article and one has to choose a few broad types. It is proposed to confine the scope to some examples of thermal reactors only, since it is these that have been extensively built. As a matter of fact the first chain reaction was obtained by Fermi and his collaborators in 1942 at Chicago, U.S.A., in a thermal, heterogeneous, graphite moderated natural uranium reactor. We start with the description of a similar reactor now working at Brookhaven National Laboratory, U.S.A.

The reactor proper is a graphite cube of 25 ft sides, separated into

Fig. 1. Model of Brookhaven Research Reactor

two equal halves by a gap of 2.75 in. in the vertical east-west plane (Fig. 1). This cube is constructed from 60,000 graphite bricks giving a total weight of 700 tons. Through this cube pass 1368 round parallel channels (of cross sectional area 5.6 in^2.) in the north south direction arranged on a square lattice with a spacing of 8 in. between centres. Sufficient number of these channels are filled with 'fuel rods' to bring the reactor to criticality.

The 'fuel rod' for this reactor is a cylindrical rod of natural uranium of 1.1 in diameter and 11 ft length encased or 'canned' in an aluminium casing (Fig. 2 *a*). This aluminium cartridge has six equally spaced longitudinal fins running across its entire length. Canning of uranium rods is essential for two reasons, (*i*) to prevent oxidation of uranium and (*ii*) to prevent the fission fragments, which are highly radioactive, from escaping into the surroundings. The total mass of uranium loaded in the reactor is about 100 tons.

The extra graphite left on all sides of the active core serves to send back some of the neutrons which would have otherwise escaped from the system. For this reason, this extra graphite is referred to as *reflector*.

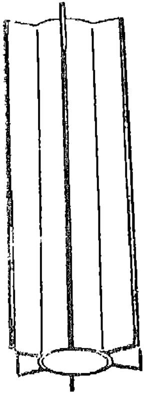


Fig. 2. *a*

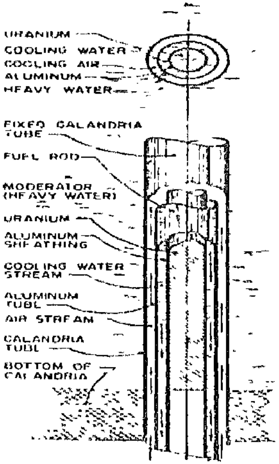


Fig. 2. *b*

Besides the channels described above, there are a number of other channels in the core and the reflector, which serve to take out beams of neutrons for experimental purposes, and also for operating *control rods*. The control rods are made of steel alloy containing a small percentage of boron which is a very good neutron absorber. By moving these rods in and out of the core the power level of the reactor can be controlled. Every reactor also has a number of *safety rods*, which are so arranged that under normal working conditions they stay out of the reactor, but should anything fail, like electricity, water supply or any part of the complicated machinery, these rods are rapidly pushed in, stopping the chain reaction.

This reactor normally works at a power level of 30 MW, i.e., heat generated per ton of uranium is 30,000/100 = 300 KW/Ton (1 calorie per sec. per cm^3 of uranium). This comes to nearly 1 calorie per sec. per cm^2 surface area of the rod. Means have therefore to be provided for removing this large quantity of heat as otherwise the temperature of the assembly would soon reach abnormally high values. In the BNL* reactor, the rods are cooled by forcing air through the channels. Cold air enters at the centre of the reactor through the gaps and flows out through the channels in both directions. The fins provided on the aluminium casing help to improve heat transfer from the rods to the air.

When the reactor is working at full power, the average number density of thermal neutrons in the core is about 25×10^7 neutrons/cm^3. However, in reactor work it is more customary to talk of *neutron flux*, which is defined, as neutron number density times the average velocity, rather than of number density itself Since for thermal neutrons, average velocity is nearly 2×10^5 cm/sec., we see that the thermal neutron flux in the BNL reactor is 5×10^{12} neutrons/cm^2 sec.

The flux of γ-rays inside a reactor is also very large Because of these high neutron and γ-ray fluxes in the core, a lot of these radiations stream out from the core. Whereas a flux of γ-rays of about 1000/cm^2 sec. or a fast neutron flux of about 25/cm^2 sec or a thermal neutron flux of 600/cm^2 sec is considered to be about the maximum that the human body can stand without ill effects, the total flux of thermal and fast neutrons and of γ-rays at the outer faces of the cube would be of the order of 10^{10}/cm^2 sec. Therefore some protection has to be provided for people working around the reactor.

Just beyond the graphite cube in north and south directions are two chambers, meant for air circulation. Enclosing these chambers and the cube are 6 in. thick iron plates, which are also cooled by air. This is called the thermal shield. Beyond this follows 5 ft. of high density concrete, called the biological shield. Outside this assembly, which now has a width of 38 ft. and a length of 55 ft., the neutron and γ-ray fluxes are below the *tolerance value*. The shield is penetrated by a number of openings, required either for loading or unloading the fuel cartridges or for experimental purposes. When not in use these holes are plugged in to prevent the escape of neutrons and γ-rays through them.

There are a number of other similar reactors working in different countries.

HEAVY WATER MODERATED REACTORS

Heavy water moderated reactors have been built using for fuel, either natural uranium or uranium enriched with U^{235} isotope. Enriched uranium is used in reactors where in a small size very high neutron flux is

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* Brookhaven National Laboratory.

Laboratory, U.S.A. We shall here consider in some detail only heavy water moderated reactors using natural uranium as fuel. A few examples of this are the Swedish heavy water reactor, NRX reactor at Chalk River, Canada, and CIR reactor at Trombay, Bombay.

Let us consider the CIR reactor, built by Canadians for us at Trombay

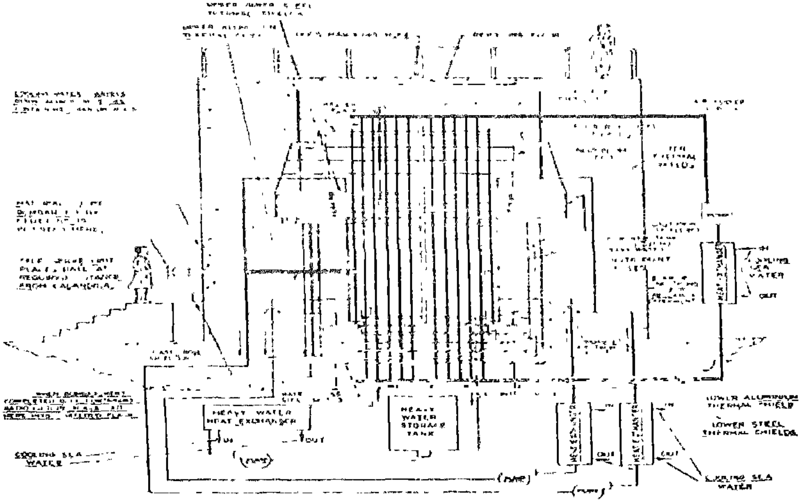


Fig. 3. Schematic diagram of Canada India Reactor

(Fig. 3). It is very similar to their own NRX reactor. The 'active core' is a cylindrical aluminium tank (called the calandria) about 9 ft. in diameter and 11 ft. in height. There are about 200 aluminium tubes all running through the entire length of the tank, parallel to its axis. In these tubes can be placed uranium rods, control rods, etc. The uranium rods are 1.36 in. in diameter and 10 ft. long encased in aluminium (Fig. 2 *b*). There is an outer sheath, also of aluminium and in the annular space heavy water is circulated to cool the rod. About 190 of these rods are needed to make the reactor critical. The total mass of uranium is about 10 tons whereas heavy water used is about 21 tons.

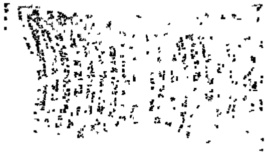
The reactor was designed and expected to run at a power level of 40 MW, and a maximum flux of about 5×10^{13} neutrons/cm^2 sec.

The aluminium tank is surrounded by two concentric rings of graphite 9 in. and 24.5 in. in thickness These act as reflectors. The thermal shield is in the form of two concentric cast iron cylinders, each about 6 in. thick. Eight feet of concrete surrounds this structure Thermal and biological shielding is also provided at the top and below the tank.

The number of experimental facilities available with this reactor is very large. Provision is also there for putting thorium rods in the reflector. The most abundant isotope of thorium is $_{90}Th^{232}$ which on absorbing a neutron, emits two β-particles in succession and converts itself into $_{92}U^{233}$

Like $_{92}U^{235}$, this isotope of uranium is also highly fissile and can be used as fuel in reactors. Unfortunately thorium, by itself cannot be used as fuel in reactors and must first be converted into U^{233} by irradiating it with neutrons. U^{233} can then be separated from thorium by chemical methods At one time it was thought that it may be possible to breed more U^{233} than the amount of U^{235} (or U^{233}) burnt. This would have meant that if one had, to start with, an amount of U^{235} which was sufficient for building one critical system, then by surrounding it suitably with thorium, one could produce more U^{233} than the amount of U^{235} consumed. In this way, without requiring any further U^{235}, we could have gone on burning thorium. This would have been an ideal situation for India where uranium deposits are comparatively meagre and thorium abundant. However, as we now know this dream will not be realizable in practice at least for a number of decades. The ratio of U^{233} produced to U^{235} consumed is usually less than one and only in extremely complicated thermal reactor systems can it be made to approach unity

LIGHT WATER MODERATED REACTORS



a b

Fig. 4. Fuel elements in the Apsara (a) side view (b) top view

To distinguish between D_2O and H_2O, ordinary water is often referred to as light water. We shall describe a type of thermal, heterogeneous, desired, an example of this being the CP-5 reactor at Argonne National light water moderated enriched uranium reactor, called the 'Swimming Pool Reactor'. Here the fuel is in the form of plates rather than rods as in the earlier type of reactors Uranium enriched to about 50 per cent with U^{235} isotope is alloyed with aluminium. A plate of this alloy of about 0.5 mm. thickness and 7.6 cm × 63 cm size is sandwiched between two aluminium plates of about the same thickness (Fig. 4 *a*). In a typical reactor, eighteen such *fuel plates* are fixed equidistant from each other to form a *fuel element*, 3″ × 3″ × 25″. (The fuel plates are curved a little to ensure that even when their temperature changes, they will stay equidistant). A 5 × 5 or similar assembly of the fuel elements is placed inside a deep water tank. The water that now fills the vacant spaces between plates serves both as a moderator as well as a coolant. Water outside the active core acts as a

Fig. 5. Canada India Reactor—a view of the reactor face.

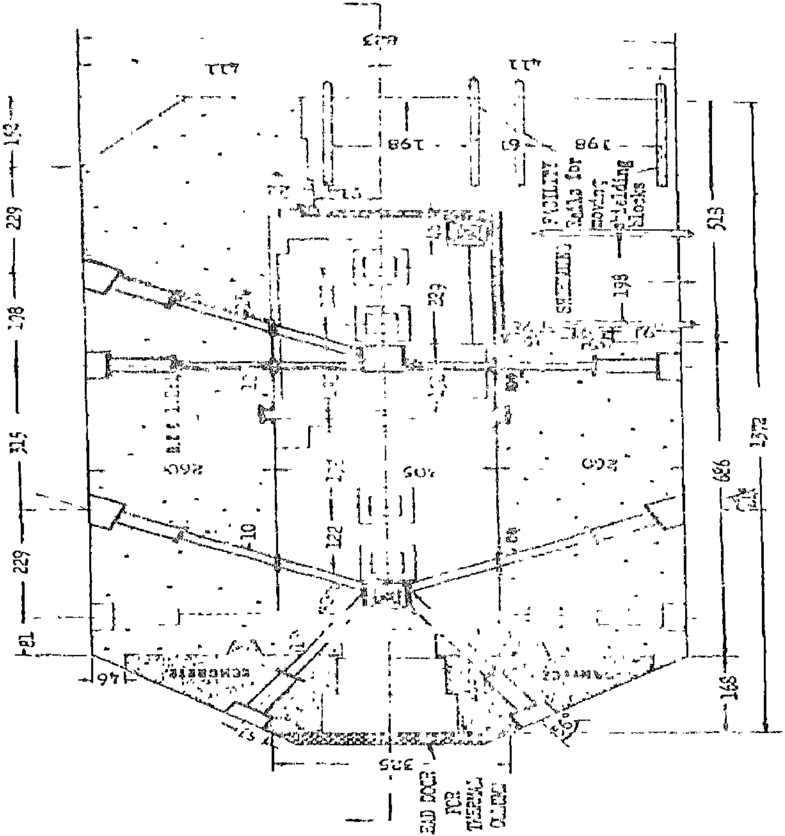


Fig 6. Plan of the 'Apsara'

reflector and also as a biological shield. The amount of U^{235} needed to make such a reactor critical is about 3 kg.

This type of reactor is inherently safe and since usually the water tank is open at the top one can observe the active core directly. To start with a number of reactors of this type were built in America and our own reactor 'Apsara' at Trombay built in 1956 (Fig. 6) is a slight improvement on the Bulk-Shielding Reactor (1950) in Oak Ridge National Laboratory. The inside dimensions of the water tank of Apsara are 28 ft. × 10 ft. × 28 ft. The core (obtained from U.K.) is suspended at a depth of 22 ft. below the the water surface from a movable trolley at the top of the tank. Outside dimensions near the base are 45 ft. × 27 ft.

The reactor was designed and expected to run at 1 MW power. Besides the three types of reactors discussed above, there are a number of other types that have been tried. For example there are the 'water boiler' reactors. These essentially consist of a stainless steel sphere (about 1 ft. in diameter) to which are joined two tubes diametrically opposite to each other. This is mounted with the tubes vertical and the sphere is surrounded by some reflector. When 'soup', which here is a mixture of some suitable salt of enriched uranium in some liquid, usually water, is slowly introduced through the lower tube into the sphere, at a certain stage this assembly can become critical. In this case the critical mass of U^{235} is about ½ kg.

A number of fast and intermediate reactors have also been built but we will not consider them here. It may however be mentioned that *power reactors* are in principle similar to one of the experimental reactors discussed above, the difference being that they run at a much higher power and that the coolant (water or gas) leaves the core at a high temperature, which is then used to drive turbines and generators.

RADIOISOTOPES IN DAILY LIFE

I C. MENON

Department of Science Education, National Council of Educational Research and Training

Radioactivity discovered more than half a century ago now plays an important part in our everyday life. Artificially radioactive materials, made available through the nuclear reactors have proved extremely valuable, not only in the laboratory but also in such practical fields as medicine, agriculture and industry. It has been said that radioactive tracer techniques alone introduce the most powerful analytical tool since the invention of the microscope. The radioactive substances are popularly known as 'isotopes' though in fact the term embraces non-radioactive as well as radioactive atoms.

The existence of atoms of the same element with different atomic weights was established by the chemist, Soddy, at the turn of the century. It was he who gave the name 'Isotope' derived from two Greek words meaning 'the same place' and referring to their identical position in the periodic table of the chemical elements. Their existence was established by studying the movements of electrically charged atoms in magnetic fields, and the development of Aston's mass spectrograph in 1919 showed that many of the natural elements are composed of atoms with different masses? This greatly strengthened the concept of a unit structure for the atom and removed a lot of anomalies. For, although the atomic weights of many elements are almost exact multiples of that of hydrogen, there are some glaring exceptions. Chlorine, with atomic weight of 35.5 is one of these and it was now shown that natural chlorine consisted of two isotopes of masses 35 and 37 present in proportion of about 3 to 1 in all natural samples of the element.

By upsetting the balance of neutrons and protons in the nuclei of the natural atoms, we can now produce isotopes which have too many or too few neutrons in their nuclei for stability. These isotopes are radioactive in the same sense as some of the heavy natural elements are radioactive, and their nuclei will tend to regain stability by emitting some form of radiation.

The materials to be irradiated are generally enclosed in aluminium cans and inserted into an endless belt made of graphite blocks which can be wound into position near the centre of the atomic pile. After being thus exposed to the neutrons for a suitable time, the materials (now radioactive) are withdrawn by winding the belt back so that the cans are brought to the outside of the reactor (heavy lead screening is needed to protect operators from the radiations). The radioactive material is to be handled with a degree of care which depends on the amount and type of radioactivity it contains. Highly active samples are manipulated by remote control behind lead, or thick concrete walls. Less active ones can be handled with suitable tongs.

Isotopes as Labels

We have in radioactive isotopes all the essentials of a very powerful research tool—a means by which atoms can be followed and identified. For, although a radioisotope behaves chemically like a natural sample of element to which it belongs, it can be detected directly through its radioactivity, which is unaffected by any chemical or physical treatment it may be given. The measured radioactivity of a sample is an accurate indication of the amount of radioactive material which it contains. This is true whether the sample is a solid, a liquid or a gas and in whatever chemical combination the radioactive atoms may appear. By a simple measurement of the radiations emitted, a radioisotope can thus be traced through all manner of complicated chemical reactions without the use of chemical analysis. Sometimes when penetrating radiations are emitted, the measurements can even be made from outside the containing vessel, without disturbing the chemical process at all.

It is not even necessary that a chemical to be followed in this way shall be composed entirely of radioactive atoms. For, if radioactive and stable isotopes are once uniformly mixed together, and in the same chemical form, any subsequent chemical treatment affects stable and radioactive isotopes in exactly the same way and they will appear in the same proportions in any sample. The radioactivity of a sample is now a measure of the total number of atoms of the original mixture it contains. Just as the movements of a whole flock of birds can be deduced by marking some of their number with identification rings, so the behaviour of the whole of a sample of a chemical element can be shown if some of its atoms carry a radioactive label. This is the basis of the radioactive tracer method which in recent years has been employed in almost every branch of scientific research and is certainly the most versatile of all radioisotope techniques.

Wear Measurement

Radioactive tracer methods have been used with great success to measure the wear of machine tools and engine components. Cutting tools used in metal working lathes have sharpened tips made of a hard metal containing tungsten and cobalt. However good the tools, the edge is slowly worn away by friction with the metal it is used to cut. A good turner generally adjusts his lathes so that the tool wear is small and, by using suitable oils to lubricate the work, reduces wear to a minimum. The rate of wear is so small, however, that its measurement was virtually impossible until radioactive techniques were used, and information about the efficiency of various lubricants was obtained only at the expense of long tests in which the tools were worn to destruction.

It happens that both tungsten and cobalt are particularly easy to be made radioactive in a nuclear reactor, so that if the tool tips are made radioactive before being used in the cutting process, particles of wear debris weighing as little as one ten-millionth of an ounce can readily be detected and measured by means of their radioactivity. It is found generally that all the material worn from the tool sticks to the metal swarf which is easily collected and packed around a detector for measurement.

The use of radioactive tracers for measuring the wear of engines offers even greater advantages. For measuring the wear of different components of an engine depends enormously on its speed and loading conditions, and lubricants in most of these parts are quite inaccessible once the engine is assembled. In the orthodox methods of measurement the engine is dismantled after tests, which may last for hundreds of hours, in order to weigh the worn parts or measure them with a micrometer. This is another difficulty, for it is then almost impossible to reassemble the engine exactly as before to repeat the tests under different conditions. The amount of abraded radioactive atoms in the lubricating oil can be used as measure of total wear without dismantling the separate components.

A number of similar uses can be listed. Resistance to wear has thus been tested on shoe soles, floor waxes, road surfaces, automobile tyres, paints and concrete as well as on many metals Methods of electroplating silver have been improved, so also the quality and effectiveness of soaps and detergents, tooth pastes and even cosmetics. Such difficult problems as the measurement of the penetration of preservative chemicals into a telegraph poles or other wooden beams have become simple. All such uses are examples of tracer action in which a relatively few radioisotope atoms reveal what is happening to all the countless other atoms because these few can talk by means of their rays.

In Agriculture

Farmers everywhere must cope with a large number of unknown factors even when their information is of the best so that many of their methods are still based on tradition rather than knowledge. An example is in the use of fertilizers which are a major item in the cost of food production. Here radiophosphorus has proved very useful. Used as phosphate fertilizer, it instantly reports what the plant has done with it.

Thus Swedish investigators have found that phosphate in a fertilizer is taken up by the plant roots almost immediately when it is spread on the soil ; there is no delay Researches in America have shown that pasture grasses take up phosphate that is spread on their leaves and on the tops of the sod so that there is no need for ploughing. Very large savings were made by tobacco and cotton farmers after the discovery that these plants together with maize and sugar beets take phosphate from the fertilizer only during the early stages of their growth and that phosphate is wasted if it is applied later. On the other hand, it has been shown that potatoes can profit from the fertilizer throughout their entire growth. Further tracer researches have shown that phosphoric acid added to irrigation water is just as effective as dry phosphate spread on the soil.

Even flies, mosquitoes, and locusts have been made radioactive by feeding on materials that contain radioisotopes and, thus marked for identification, have betrayed their habit and flight pattern which has then led to better control by their ability to break the toxic chemical down into more fatal insect poisons.

Storage of Root Crops

It has been found that the exposure of potatoes to moderately large quantities of gamma radiation (about a quarter of the amount needed to sterilize an insect) delays their sprouting altogether. Potatoes irradiated in this way are found to retain their firmness to eighteen months, while untreated potatoes through moisture losses in sprouting become flabby and inedible in a much shorter time.

Radiation in Genetic Changes and Plant Breeding

When seeds, pollen or growing buds are exposed to nuclear radiations, changes sometimes occur in the structure of the resulting plants through the action of the radiations on the growing cells. Some of these changes are hereditary and can be passed on through seeds to form a new strain of plants. Some of the new strains which appear naturally from time to time are believed to be due to the effect of cosmic rays and of radiations from natural radioactive substances.

The use of radioactive sources speeds up the process and enables the plant breeder to select from a variety of new strains. Most of the changes are undesirable (as they also are in nature) but a few are important in agriculture. Improved types of cereals and peanuts have already been obtained as well as types of grains that are better adaped to specific conditions of rainfall or soil fertility.

These developments require that a new stimulus should be imparted to science education in schools and to technical training in this country. In this context, the programme of science education at all levels must forge ahead and orient our school systems to the astounding and ever expanding vistas of modern science

FOOD AND ITS INCREASED PRODUCTION

N. R. DHAR

Sheila Dhar Institute of Soil Science, Allahabad

Hunger is the oldest enemy of man Hence, man's first need is food. Wars amongst mankind revolved round food which was wealth and therefore the main economic factor in the life of the primitive man. Even as food was the basis of the simple economics of our ancestors, it is none the less important in our modern civilization. No nation, certainly no large nation, has ever truly conquered hunger, the oldest enemy. A soldier, who has seen men in all stages of starvation, has reported that if a man misses his meals one day, he is likely to lie. If he has no food for two days, he will steal, and if he starves for three days, he will kill.

It is no wonder, therefore, that when the learned men and philosophers and even the Nobel Laureates of Germany met during the World War I, when there was acute shortage of food, they usually talked of foods, drinks and their substitutes. In the last European war, two of the slogans were : 'Food will win the war and write the peace' and 'Food for victory'. For all of us food is the largest item in the cost of living and the most potent factor affecting health. Wise use of food means much for welfare and longevity.

Food is not a medicine nor is it prescribed on the basis of a chemical formula or equation. The fact that disease or ill health may result from lack of food or its improper selection has to be learnt by every body.

In the publications of the Food and Agriculture Organization of the United Nations, Rome, the Food Balance Sheets of several nations have been recorded. In the following Table these records are summarized.

TABLE I. FOOD SUPPLY (1958—59) PER CAPITA PER DAY

	Calorie	*Total Protein (gm.)*	*Animal Protein (gm.)*	*Fat (gm.)*
1	2	3	4	5
Europe and North America				
Austria	3050	87	43	87.8
Belgium-Luxemburg	2930	86	45	101.6
Denmark	3350	92	57	140
Finland	3070	92	50	—
France	2950	96	49	88.1

1	2	3	4	5
W. Germany	2990	80	45	100.8
Greece	2650	85	23	64.6
Ireland	3500	96	39	117 6
Italy	2630	76	26	57.1
Netherlands	2940	78	43	—
Norway	3080	86	50	125.1
Portugal	2430	71	26	—
Sweden	2890	81	52	127
Switzerland	3180	93	52	113 5
United Kingdom	3260	85	50	123 1
Canada	3110	95	62	123.5
U.S.A.	3110	93	65	135
Latin America				
Argentina	3100	104	65	107 1
Brazil	2540	65	20	45.7
Chile	2550	79	28	47.8
Equador	2130	51	13	—
Honduras	2260	57	10	53.7
Mexico	2420	66	16	—
Paraguay	2690	69	29	—
Peru	2070	55	12	36 3
Uruguay	3090	99	64	126.2
Venezuela	2000	58	24	45
Far East				
Ceylon	2110	43	6	33
India	1800	47	6	22.6
Taiwan	2330	57	14	—
Pakistan	2010	49	8	—
Japan	2220	68	17	16 5
Africa and Near East				
Israel	2750	84	33	—
Turkey	2890	92	14	41.7
Union of South Africa	2660	74	31	59 9
Egyptian Region	2640	78	13	35.2
Oceania				
Australia	3200	91	60	122.1
New Zealand	3430	106	72	148.7

It is generally accepted that one million calories are needed per capita per year.

TABLE II. PRESSURE OF POPULATION ON LAND AND USE OF FERTILIZERS

	Persons per hectare of arable land	*Fertilizer used in kg per hectare*
Japan	11.7	97.3
United Kingdom	9.2	59.4
Netherlands	8.8	336.6
Switzerland	8.3	31.3
Belgium	7.5	177.9
Egypt	7.2	37.6
India	6.6	1.0
Korea	4.88	33.4
Brazil	4.2	0.2
Mexico	3.7	1.0
Germany	3.5	107.6
Norway	3.5	43.7
Peru	3.5	31.7
Australia	3.4	13.7
Italy	3.3	27.0
Greece	3.2	7.4
Czechoslovakia	2.5	17.3
Eire	2.3	31.4
Turkey	2.2	0.02
Union of South Africa	2.1	9.4
New Zealand	2.0	58.1
France	2.0	37.2
Yugoslavia	2.0	0.9
Poland	1.9	7.6
Sweden	1.7	33.8
Spain	1.6	18.9
Hungary	1.6	2.5
Bulgaria	1.6	0.03
Rumania	1.5	0.15
Finland	1.4	20.3
Denmark	1.4	52.5
Algeria	1.3	3.3
Estonia	1.0	12.9
Latvia	0.9	16.0
Lithuania	0.9	8.5
U.S.A.	0.9	9.9
Tunisia	0.9	3.1
Morocco (Fr.)	0.9	1.0
Chile	0.8	2.8
U.S.S.R.	0.8	3.0
Canada	0.5	3.0
Argentina	0.5	0.02
Australia	0.5	21.7

The foregoing Table clearly shows that the eastern and south American nations are ill-fed and in all respects, the food consumption in India is easily the most inadequate Hence, we have to face the baffling fact that we have not been able to meet the first need of the common man and help him to maintain his health. It is a wonder that he has not revolted so far !

TABLE III. LAND USED IN SEVERAL COUNTRIES AND CONTINENTS

	Total area in million hectares	*Agricultural area percentage*	*Arable area of total area percentage*
U S A. excluding mountain and Pacific States	473	70.1	28.8
Total Europe	494	47.3	30.5
India	328	48.1	45.7
Western Europe	359	43.4	26.3
North America	2150	23.7	10.8
Latin America	2056	21.2	4.4
Near East	1333	28.2	5.8
Far East	2081	29.5	15.7
Africa	2306	31.4	9.6
Oceania	853	47	2.8
U.S.S.R.	2227	15.6	10.1

This shows that India has very little land under grass and, hence, milk is scarce.

TABLE IV. FARM LAND AVAILABLE PER PERSON IN EUROPE (1955)

	Hectares		*Hectares*
Belgium-Luxemberg	0.20	Austria	0.59
Netherlands	0.21	Sweden	0.62
West Germany	0.28	Finland	8.66
Norway	0.30	Denmark	0.70
United Kingdom	0.38	France	0.77
Italy	0.43	Spain	0.98
Switzerland	0.44	Greece	1.04
Portugal	0.59	Ireland	1.61

	Agricultural land per capita (in hectares)	*Total land per capita (in hectares)*
Europe	0.58	1.21
U S.S.R.	1.63	10.58
Far East	0.45	1.53
Near East	2.83	10.0
North America	2.87	12.1
Latin America	2.81	11.56
Oceania	2.90	61.70
Africa	4.40	14.0

TABLE V. WORLD FERTILIZER PRODUCTION (F.A.O PRODUCTION YEARBOOK 1959)

		N_2 production in million tons		*P_2O_5 production in million tons*		*K_2O production in million tons*
Europe		3.56		3.9	7.3 million tons	5.08
N America		2.41		2.36		2.11
Latin America		0.32		0.21		0.02
Near East	8 million tons	0.24	8 million tons	0.8		0.07
Far East		1.33		0.54		
Africa		0.08		0.24		
Oceania		0.04		0.65		
India		0.082		0.038		
Pakistan		0.0102		0.006		
Japan		0.992		0.323		

In the following table the food produced per acre of arable land is recorded. Results show that cereals and potatoes are most efficient in the supply of calories.

TABLE VI HUMAN FOOD PRODUCED PER ACRE PER YEAR

	Weight of food lb.	*Digestible protein lb.*	*Energy million calorie*
Milk	3750	125	1.22
Cheese	375	97	0.73
Butter	170	2	0.61
Pork, 600 lb. live weight	470	39	1.15
Poultry, 475 lb. live weight	290	56	0.31
Mutton, 415 lb. live weight	190	25	0.23
Beef, 370 lb live weight	215	32	0.22
Corn, 60 bushels	3350	300	5.34
Wheat, 34 bushels	2[illegible]50	190	3.06
Soy beans, 27 bushels	1650	500	2.62
Oats, 60 bushels	1350	150	2.15
Irish potatoes	10000	110	3.26
Sweet potatoes	10000	90	4.88

It has been stated by H. Bennet, that poor soils make poor people and poor people make the soil worse. Moreover, Louis Bromfield, in his book *Malabar Farm* has observed that the mineral deficiencies of poor or worn out soil affect not only the living standard of the people attempting to make a living upon it but also the standards of health, vitality, intelligence and initiative which are so fundamental a part of the real wealth of nations. Bromfield has always emphasized that artificial fertilizers are useless without humus or organic matter.

John B. Abbot of Vermont, U.S A., has stated as follows :

'If all accumulated soil wisdom of a hundred generations of master farmers were boiled down to just three sentences, one of these sentences certainly would be : *Provide for regular and frequent replenishment of the supply of organic matter in the soil.*' Moreover, Sir E. J. Russell has unequivocally declared that artificial fertilizers lead to soil deterioration not only in continuous cropping but in rotations as well.

Once richly productive areas, like North Africa (once the granary of the Roman Empire), the valley of the Tigris and the Euphrates and vast areas of India and China, have ceased to grow even sufficient food for the population of the immediate areas or have been virtually turned into desert regions chiefly due to depletion of humus. The richest soils on the earth--the prairie corn belt and the vast mid-western plains, the black soil belts of Texas, the Ukraine, Mississippi and Alabama—are essentially grass legume-made, phosphate and lime-rich soils.

The essential plant nutrients, e g , nitrogen, phosphorus, potash and trace elements are very important assets for agricultural production. Continued loss of these assets from land leads to agricultural bankruptcy and hunger ; dire poverty, malnutrition and debilitation set in for the common man whose welfare depends largely on production from land. The return of the nutrients in agricultural and plant wastes and those from cities aided by cheap phosphate sources to poor agricultural land, as occurs in India, could change a decreasing agricultural production to a steadily increasing economy.

In the U.S.A., the corn belt area and in other parts, lands rich in humus and a favourable climate form the basis of crop production. By the application of science and technology crop production has been pushed up enabling this country to export approximately 10 per cent of the food produced. But the great natural advantage of this country is the large amount of land under cultivation and even today about 3 acres are available per capita (520 million acres for 180 million persons). It is interesting to note that on an average the amount of nitrogen applied per acre in the U.S.A., is low and is of the order of 4 to 5 tons per acre. If the nation is unable to conserve the humus capital of their land the fertility is bound to fall.

Prof. R. H. Bradfield, President of the 7th International Soil Science Congress, took exception to my statement : 'No nation, certainly no large nation, has ever truly conquered hunger, the oldest enemy of man'. I had to point out to him that as the population is increasing fast, the surplus of 10 per cent may not last long and that various parts of this great country are still poor, as will be evident from the following lines : 'New England crop farmers by and large have had a struggle just to get along almost from colonial times. The Southern Appalachians seem to be a permanent poor house. Topography, obsolete methods, lack of capital and possible lack of a diet adequate to supply the requisite energy and thought, all conspire to make this region sad indeed. Throughout the south where cotton and tabacco have depleted the soil, rural poverty is rampant. Farther, south-west Texas has areas of almost continuous poverty. In New Mexico and Arizona, particularly amongst the Spanish Americans and Indians, poverty is the rule. Before World War II, we stood arraigned as the most wasteful people in all history. Nowhere else had a people taken such a rich virgin territory and in a short three centuries ruined large parts of it for all time and semi-destroyed other parts, while busily trying to do away with the rest'. (L. Haystead and G. C Fite, 1958). Similarly, in Oklahoma, Virginia, Alabama, Georgia, Kentucky, North and South Carolina, farmers are not well off. In a recent article Prof. W. B. Bollen has stated that more crops are being produced in the U. S. A., but lands are losing fertility.

NITROGEN IN CROP PRODUCTION

It has been frequently stated that nitrogen is the key element in crop production. This is evident from the following Table which shows the yield in different countries expected by an application of I kg. of plant nutrient :

TABLE VII. ESTIMATED AVERAGE INCREASE IN YIELD IN KGS. IN TILLAGE AND GRASSLANDS FROM I KG. OF PLANT NUTRIENT

Country	*Crops in Rotation*			*Permanent Pastures*		
	N	*P*	*K*	*N*	*P*	*K*
Norway	9	3	5	11	6	4
Sweden	14	11	7	14	11	7
Denmark	18	4	2	12	5	3
United Kingdom	16	5	5	—	—	—
Ireland	20	8	8	—	—	—
Netherlands	19	6	3	10	6	4
France	19	5	2.1	—	—	—
Germany	19	8	4	9	10	5
Switzerland	18	8	4	9	10	[illegible]
Greece	15	5	3	—		—
Italy	11	3	—	12	4	3
Average	16	5	4	11	7	4

It seems that there is a close relationship between climatic conditions and the effect of nitrogen. The lowest nitrogen influence has been observed in Norway, Sweden, Italy and Greece Lack of water has very often been a factor which restricted the production. The influence of phosphate and potash on crop yield is much lower than that of nitrogen.

In the Oxford Economic Atlas of World (Oxford University Press, 1959) the following results regarding yield are recorded :

TABLE VIII. INCREASE IN YIELD TO 1 KG. OF N_2 PER HECTARE

	Wheat	*Rice*	*Potatoes*	*Grass (or hay)*
Kg. per hectare	17	17	84	17

It has been stated that yield increases of this order are obtained when the use of nitrogen is not excessive. After a point, successive increments of fertilizers bring diminishing increments of yield

The Indian Council of Agricultural Research has reported that on average the rice production in India is 10 times the amount of N_2 applied when the dose is not large.

The United Nations Korean Reconstruction Agency, in their report (*Agriculture, Forestry and Fisheries in South Korea*, New York Columbia University Press, 1954, pp. 92-102) have reported that 1 kg. of N_2 as ammonium sulphate can produce 12-14 kg. of brown rice and 14-28 kg. of rough barley in South Korea. Similarly 1 kg. of P_2O_5 from superphosphate can yield 14 to 19 kg. of brown rice in some places, whilst in other places 4 to 5 kg. of brown rice are produced per kg. of P_2O_5.

Prof. K. A. Bondorff, Director, State Laboratory, Lyngby, Denmark has reported : 'I will only say that the consumption of fertilizers could profitably be increased by 60 per cent thereby causing an increase in yield of 4 per cent. I think we can easily agree that there must be such a thing as a maximum profitable consumption. But how to calculate this quantity? I should like to stress that the answer is a very important one. It is important to the single farmer who, of course, wants to benefit as much as possible from the use of fertilizers. It is important to the national economists and to the politicians who want to estimate to what extent their country can supply itself with food. And last but not least, it is important to the manufacturers of fertilizers wanting to know the maximum quantity they can hope to sell. The question is as difficult to answer as the answer is important. But I think the answer will be important in still another way. The answer might be useful to people, including many politicians, who know too little about agriculture. When it is emphasized that agriculture in the future will have increasing difficulties in meeting the demand of food, these people point to the role fertilizers have played and believe that by increasing the use of fertilizers every demand can be met. Looking backwards this point of view can be understood But, looking forward the picture is quite different. The possibilities of an increased use of fertilizers are, in my opinion, often overestimated, the law of diminishing return too often neglected'.

Prof Bondorff further stated :

'The phosphoric acid condition and the potash condition of the soil has to be in order, i e. sufficient quantities of these two nutrients have to be available in the soil for plants in order that they can utilize the expensive nitrogenous fertilizer and the water, etc In other words, it does not pay to have the yield determined by the relatively cheap phosphoric acid and potash nutrients. Then one should give as much phosphoric acid and potash as will be sufficient for the plants.' (*The Effective Use Fertilizers including Lime*. O.E E C. April, 1957, p. 87).

Consequently, for over 30 years we have carried on systematic research work and have developed an alternative method of land fertility improvement by ploughing all kinds of organic matter with cheap phosphates sources like basic slags and rock phosphate for fixing atmospheric nitrogen in the soil and supplying available nitrogen, phosphate and potash to crops. It seems that at least 250 million tons of available nitrogen are necessary for the food, fibre and fodder production of the world. But only 3 per cent of it comes from artificials, 2 per cent from farmyard manure, but the rest comes from soil, the nitrogen of which appears to have been derived from the thermal and photochemical oxidation of carbohydrates photosynthesised. Hence, carbohydrate manuring aided by different calcium phosphates must be well organized all over the world to supply 90 per cent of the nitrogen need of crops.

In our extensive researches on alkali land reclamation we have obtained excellent results by applying a mixture of bone meal and straw or molasses of pressmud in Rajasthan, Mysore, Uttar Pradesh and Bihar. Similarly, in composting of plant residues and city refuse, basic slag and rock phosphates have been found to increase the nitrogen fixation. The unphosphated compost contains 0.5 to 0 8 per cent nitrogen, whilst the nitrogen content of the phosphated compost is of the order of 1 to 2 per cent, and the available nitrogen and phosphate also increase readily. We have discovered that sunlight is utilized in nitrogen fixation in soils and composing for increasing the nitrogen content of composts.

In recent years we have carried on field experiments in different parts of this country as well as in Europe and Africa. In the following Tables some of our results are recorded :

TABLE IX YIELD OF PADDY GRAIN IN KG. IN ANACUR (ALLAHABAD)

Treatments	1	2	3	4	5	6	7
Soil alone (control)	11.50	12.25	10.75	11.00	13.00	10.25	68.75
Soil Wheat Straw (10 tons/acre)	18.00	17.25	19.50	16.50	18.50	18.25	108.00
Soil Wheat Straw, P_2O_5 as Tata basic slag	23.25	22.75	23.50	24.60	21.50	23.50	139.00
Soil *Kans* (*Saccharum spontaneum*) 10 tons/acre	16.75	15.50	16.25	17.75	15.00	16.00	97.25
Soil *Kans* P_2O_5 as Tata basic slag	21.75	21.25	22.25	22.75	20.50	21.25	129.75
Soil Sunnhemp (*Crotalaria juncea*)	15.50	14.75	16.75	15.25	15.75	16.00	94.00
Soil Sunnhemp P_2O_5 as Tata basic slag	18.75	19.25	17.50	18.50	19.50	18.50	112.00
Total	125.50	123.00	126.50	126.50	123.75	123.75	748.75

YIELD OF PADDY STRAW IN KG.

Treatments	1	2	3	4	5	6	Total
Soil alone	30	29	28	25	29	27	168
Soil + Wheat Straw	52	48	50	47	53	51	301
Soil + Wheat Straw + P_2O_5 as T.B.S	65	62	67	63	68	64	389
Soil + *Kans*	45	47	48	46	44	45	275
Soil + *Kans* + P_2O_5 as T.B.S.	60	63	59	64	62	60	368
Soil + Sunnhemp	42	43	39	40	44	42	250
Soil + Sunnhemp + P_2O_5 T.B.S.	54	53	55	56	52	51	321
Total	348	345	346	341	352	340	2072

MIDNAPORE FARM, BENGAL (*on Ammon paddy*)

	Grains in kg/acre			
	1958-59	1959-60	1960-61	*Average*
Control	322.40	531.60	816.43	556.80
Organic matter (straw)	362.40	762.40	985.20	703.20
Basic slag (40 lb. P_2O_5/acre)	350.80	745.20	861.60	652.40
Superphosphate (-do- -do-)	325.60	632.80	822.00	610.00
Organic matter (straw)+basic slag	390.00	784.00	974.80	714.80
Organic matter (straw) +Superphosphate	399.20	771.60	918.00	696.00

EXPERIMENTS IN SALINE AND ALKALINE SOILS OF RAJASTHAN (INDIA)

ORGANIC MATTER (STRAW OR COAL) 10 TONS/ACRE AND P_2O_5 100 LB/ACRE

	Grain in kg/acre	
	Paddy grain	*Barley grain*
Control	45.93	93.75
Organic matter (straw or coal)	126.12	175.60
Organic matter (straw or coal)+P_2O_5 (as bone meal)	203.91	241.90
Pressmud	370.18	266.25
Pressmud+P_2O_5 (as bone meal)	501.62	382.50

At my request Lady Eve Balfour of the Soil Association, New Bells Farm, Haughley, Suffolk (England), performed the following experiment: One 5.42 acres plot of land with barley was harvested by a combine harvester on 9/9/57 and the barley straw remained on the land which was ploughed up early in January 1958. To one portion of the land A (3.12 acres) ammonium sulphate at 1 cwt. N_2 per acre was applied on 17/10/57. To the second portion - B, nothing was added but in the third section—C (1.75 acres) 22 per cent basic slag was applied to the straw on 16/12/57 at 99 lb. P_2O_5 per acre. On 3/4/58 one ton and 4 cwt. of a compound fertilizer (Fison 35—25 lb. N_2, 62 lb. P_2O_5 and 62 lb. K per acre) was applied to the whole 5.42 acres plot. Barley was sown on 10/4/58 and harvested on 6/9/58. Her report was that the plot to which basic slag was added to the straw contained the largest amount of total nitrogen and produced the biggest crop of barley. The yield of barley in A with ammonium sulphate was 20 8 cwt. per acre, B (control) gave 14 cwt. per acre and C containing basic slag produced the highest yield of barley, i e. 30 3 cwt. per acre. Moreover, the Inter-African Bureau of Soils and Rural Economy are also utilizing a mixture of straw and basic slag in crop production in Africa.

CONCLUSION

Our experiments show that organic matter such as straw, plant residues and grasses, when incorporated in the soil or composted, not only improve the physical properties of soils but also fix atmospheric nitrogen and protect the soil nitrogen and this is largely aided by different calcium phosphates including phosphate rocks and basic slags. The world reserve of phosphate rocks is of the order of 21,000 million tons and its present utilization is 30 million tons per year. Moreover, the expanding world steel industry can supply large amounts of basic slag rich in lime, phosphate, magnesia, manganese, copper, vanadium, molybdenum and other useful nutrients. Hence, increased utilisation of these cheap phosphates which are not readily washed away and are not converted into ferric, aluminium or titanic phosphates unutilizable by crops, could go a long way towards meeting the world-wide shortage of nitrogenous fertilizers.

FOOD CULTIVATION IN SOCIAL INSECTS

H. S. VISHNOI

University of Delhi

Organized farming has been one of the most important factors in the progress of human society. The same would perhaps apply to certain social insects such as the ants and the termites. Even today after centuries of progress, man is paying greater attention towards improved cultivation and building up adequate food reserves. These ensure a perpetual social life. Likewise, the ants and termites growing their own food within their nests have, to a great extent, freed themselves from a tense struggle outside their nests. The nature of food grown by these two diverse cases of social animals --man and insects—is, however, quite different.

Grades of Insect Societies

Perfect societies of insects are found only in the ants, termites, wasps and bees. Each of these lives in a kind of nest with a population of hundreds and thousands. All the members within the nest are usually the progeny of the same parents. They live in close co-operation and have division of labour. While all known species of the ants and termites are social, only a few of the wasps and bees lead such a life.

The wasps may be said to be at the lowest grade in the social organization. They make papery nests. They never store any food but only collect it in the form of sugary materials, or prey upon other insects for their daily needs. Lack of any food reserves in their nests is one of the chief factors for the repeated catastrophe of the wasps' colonies every year. Before winter, all the wasps die leaving only a few young females which hibernate or conceal themselves under some protected cover on the ground. On reappearance in the next spring, these females start a new colony. Like these annual colonies of wasps, there are also colonies of bumble bees. The latter, of course, have advanced a step further in gathering nectar and storing it as honey in small quantities.

The honey bee collects its food in a quantity greater than its daily requirement and builds large stores of honey. In adverse weather, when the bees do not go out foraging, or in case of increased demand, as in the rearing of the larvae they fall back upon their food reserves. And again, at the time of swarming some of the stored honey is taken by the old queen and by her companion workers in establishing a fresh colony leaving behind a new female to rule the old nest. The honey bee colonies persist year after year.

The termites and the ants always live in perennial colonies sometimes going on for ten, twenty or more years. These are in a way the most highly evolved social insects. Besides gathering a variety of food from outside the nest, they have even adopted a method of agriculture or growing of food. They cultivate tiny fungi, which are also called the mushrooms. These are usually grown in the subsoil gardens within their nests.

Fungus-growing Termites

Termites are the oldest of all the social insects. They appeared more than 200 million years ago, long before man came into existence. They have been principally feeding on wood, but during the course of evolution a few termites have acquired even the food growing habit. The common Indian mound-building termite *Odontotermes obesus* is one such mushroom-growing species In its nest there are large spaces and galleries filled with masses of soft spongy brownish material called the fungal beds or the fungal combs (Figs. 1, 2). These are constructed by the termites chiefly from their own excreta and thus may be compared with the compost manure in farming by man. Certain fungi like *Xylaria* and *Volvularia* are

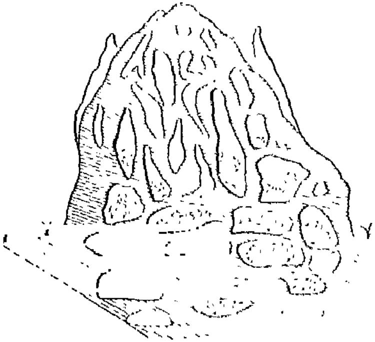


Fig. 1. Internal structure of a termite mound (diagrammatic), showing fungal chambers.

Fig. 2. Fungus garden of an Indian termite *Microtermes mycophagus* from Delhi.

grown luxuriantly over these fungal beds. The underground dampness provides the necessary moisture for the fungal growth. The mycelia grow upon the substratum of the fungal beds and usually produce a kind of white spheres which are readily eaten by the nymphs and other members of the colony. The problem of getting the 'seeds' of the desired type of the fungus is easily solved. Before the new winged males and females leave their parent nests for their nuptial flights during rains, they have already gathered a number of the spores of the fungus sticking on their bodies. Some fungal spores are even retained inside their stomachs undigested. When these new individuals found a fresh underground colony the fungal spores, both from the body and those passed out in the excreta start germinating and give rise to the new fungus gardens. The fungicultural termites are quite widespread. They are most abundant in India, Central Africa, and Australia.

Fungus-growing Ants

The fungus-growing ants are found only in South America. There are about a hundred species of these, all belonging to the tribe Attini of the subfamily *Myrmecinae*. They construct special underground chambers in which they prepare fungal beds constituted chiefly of the chewed leaf fragments and manured by their own excreta (Fig. 3). The fungus grown by the ants is usually some species of *Rhozites*. Its mycelia are never allowed to grow long. As soon as they are a few millimeters long these are bitten off and replanted. If allowed to grow unchecked the mycelia would reach a size of 6-7 inches. Inside the formicaries (ants' nests) the fungus produces little swellings called the *bromatia* which are eaten up by the ants and their larvae.

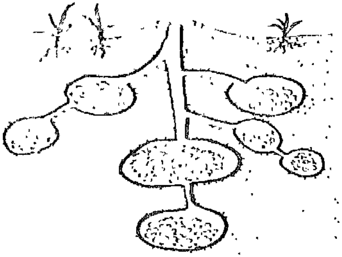


Fig. 3. Internal structure of the nest of a fungus growing ant (diagrammatic).

A subtle balance is maintained between the population size and the amount of fungal cultivation. Too few ants in the nest would be unable to keep the fungus garden in check and relatively too many ants would only starve. They also carefully regulate the conditions within the nests for a proper growth of the fungus. They would even remove certain weeds which might spring up within the mushroom gardens.

Like the termites, the fungus-growing ants also bring the fungus forming material from their parent nests. The young queens before setting out for their marriage flights store some mycelia and fungal spores in their *infra buccal chambers*, a kind of sac just below the mouth. On establishing the new colonies they grow the same material on the freshly-prepared fungal beds. The newly grown mycelia are nourished on the faeces of the queen ant who may even sacrifice some of her eggs for this purpose.

It should be noted that the fungicultural ants do not grow the same fungi as do the termites Nor does it mean that the ants and termites are closely related. In fact, the termites are older than the ants by several million years. The apparent similarity in the fungus-growing behaviour of the two, is just one of those innumerable examples that may be cited in favour of convergence in evolution.

Aerial Gardens of Ants

Some ants, again of Central America and belonging to the same tribe Attini, make aerial nests on the trees. Within their nests they grow certain plants of the orchid family, which are mostly epiphytes. But actually these plants are cultivated not so much for food but only to consolidate the soft nests by the rootlets of these epiphytes.

Harvesting Ants

Certain ants, without being food growers, only harvest it from the fields. In this way, they collect wheat and other grains or seeds of different kinds and store them in their nests. The common large black ant of India, *Camponotus compressus* often stores wheat and rice grains within its nest How these ants prevent the seeds from germinating due to the subsoil humidity still remains unexplained. Probably, they nibble off the tiny radicles as soon as they appear.

Problems relating to food growing and its storage within the nests of the two most advanced social insects, the ants and termites, are manifold. Scientists at home and abroad are busy trying to solve many of the hitherto unknown phases of the life of these social insects.

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SCIENCE IN NATIONAL DEFENCE

N. E. BINGHAM

IN WHAT WAYS CAN SCIENCE CONTRIBUTE TO NATIONAL DEFENCE?

There are at least three ways that science can contribute to the National Defence, namely :

(1) The science taught in the schools can be made more practical so that it makes a bigger difference in the lives of the boys and girls and in the contribution that they make to the community where they live.

(2) Science can be applied in assessing the short time and the long time purposes of the enemy and in adjusting one's actions in the light of these purposes. One can then predict the consequences of these purposes, if carried out, on the future of India and of South-East Asia. One can analyze the propaganda put forth by the enemy and so avoid miscalculations of what they will do. One can become better informed regarding the physical and economic factors of a conflict, and therefore, better order one's life to counter an offensive, and help others in one's own community to do likewise

(3) Students can, to a considerable extent, become scientists rather than merely becoming informed about science. As scientists they become aware of a universal order in nature, and they strive to explain that order. As a result, their own lives are brought closer in harmony with reality ; their actions become, to a greater extent, based upon reality and to a less extent upon superstition.

Let us consider first, how science may be made more practical ; second, the nature of science ; and third, how to teach science to make it more *central* in the lives of the boys and girls.

How to Make Science More Practical

Perhaps the best way to tell how this may be done is to describe a school where it was done, and where it practically remade the community of which it was a part– Holtville, Alabama.

Holtville, Alabama, was a poor community with little culture, and with little hope. A school principal with a dream took over this community. He reasoned that much of what was taught in the school had little to do with the lives of the boys and girls. Only about ten per cent of them went on for a college education. Most of them would live in poverty just as their parents had done unless his school could do something about it. What could his school do about it ? The people did not have enough to eat, and what they did eat was of poor quality. How could this food supply be increased ? They couldn't raise many garden crops for the soil was poor, and the insects would eat up the crops. And the crops would be available but for a harvest season of the year for they had no means of processing and keeping foods throughout the year. In fact, no one in the community knew what to do. They knew little about good farming practices, little about improved varieties of plants and animals, little about how to process foods, and even little if anything about what they should eat to keep healthy.

What did this principal do about it ? He talked over the problem with the school directors and leaders of the community and gained their support for a community attack on the problem. He enlisted the support of prominent businessmen and the local bank. He mortgaged his own home to procure a loan to help in the project. The first 11 grades of the school were then organized as a cooperative corporation and plans were made to use the school to carry on community projects.

Few garden crops were raised, first because they had inadequate tools for tilling the soil and second because the insects ate the crops up before the gardeners could harvest them. So the agriculture students studied how to use modern machinery in tilling the soil and how to control insects by sprays. A tractor, plough, harrow and power sprayer were purchased and for a nominal fee the high school students would go and plough a garden and fit the soil or would spray a garden at the proper time. In this way good crops could be assured. The students studied what are the best varieties of crops and vegetables to grow, purchased the seeds and provided them at cost to the people in the community. In this way excellent gardens and also field crops were produced, better than what had been produced here before. During the harvest season there were ample garden crops. But how could these vegetables and fruits be made available during the winter season ?

A cannery was established at the school and the home science people learned how to operate this cannery. For a tithe of the vegetables and fruits canned, anyone in the community could use this cannery to can the excess of the seasonal crops produced in his garden or orchard. This tithe was used to provide good school lunches at the school and to pay the cost of the machinery used in canning. This most successful venture did a great deal to improve the nutrition of the school children and of the people in the community.

There was no way to adequately care for meat. If an animal was butchered it had to be eaten right away or it would spoil. So a cooperative cold storage locker plant with a quick freezing unit was established at the school. The school children learned to operate this plant. Locker drawers, which provided a cubic yard of cold storage, were rented for a nominal fee to the people in the community. In connection with this, a meat cutting and processing plant was established. The students learned to cut meat and to cure bacon, hams and sausages; they learned to pack meat for quick freezing and for storage in the locker plant. This venture in the establishment and operation of the cold storage plant much improved the diet of the people in the community. In close work between the students and the members of the community, studies were made of better varieties of farm animals. In this way the quality of animals raised in the community was improved.

Much of the poultry raised in the community was of poor quality also. So it was decided to build at the school a chick hatchery and to hatch high quality chicks for distribution to the people of the community. In this way the egg production of the community was greatly increased and at the same time the boys and girls were learning about the selection and breeding of fine animals and how to care for them. They were also learning business methods which carried on in the community after they completed school. These projects formed the basis of much of their academic work. They were carrying on library researches in connection with the various projects; they were learning accounting and figuring in connection with the business processes; they developed skills at typing and book-keeping in connection with these business projects; they learned to operate machinery, to care for it and the principles of its operation in connection with the operations of the tractor, the cannery, the cold storage plant and other projects not discussed here.

On visiting the school one was impressed by the vitality and the self-direction of the students. They learned many semi-skilled professions; a number of them connected with agriculture, some with the machinery that they were operating, others included plumbing skills, electric wiring skills and the like. The satisfaction that they gained from learning to produce effectively and from improving the economic status of the community, served as stimulus for long and hard hours of work and of study. The entire community took on a new life because of the activities of the school.

What about the cultural facilities in the community? The school auditorium was not used much during evenings, so the school undertook to operate it in the evenings as a motion picture theatre. In this way many educational films as well as entertaining films were brought to the community.

But you say,--this doesn't sound like *school* to me. How did the children ever get into college? Did they learn to read and write and figure? Yes, they did. They learned a great deal about reading and writing and figuring in connection with the many projects. And for the last year the ten per cent that planned to go on to college took formal instruction in college subjects to be prepared to pass the entrance examinations. They did just as well in their examinations as others had done formerly, studying for 12 years in preparation for such examinations.

In India you would not organize a school just as this school was organized in Holtville. Your community organization is different from that in Holtville. You have different ways to initiate projects, and to carry out such projects. But you could have closer ties between your schools and the block organization of your villages. The concerns and decisions being made by the panchayati leaders and the reasons at the back of these decisions could be made the subject matter for the classroom. The pupils could learn much of the content of the syllabus in a meaningful way by dealing with problems they will be facing as adults, by gaining skills they will need as adults, by acquiring the assurance that they can cope with the problems which adults face.

Beyond modifying the content studied to bring it in closer harmony with the problems the youth will later face as adults, there are at least two other things that you may do to make your science more practical:

(1) You can have more experiments and demonstrations in the science classes. These experiments and demonstrations carried out largely by the boys and girls will enable them to understand and use science to a greater extent than they can ever achieve without such practical experience.

(2) You can organize very practical applied science courses of a prevocational nature—courses which yield an understanding of how the various applications of science operate and of their significance in society. These courses could be taught as after-school courses, or as science club activities. Some such courses might be :

(i) Basic electricity. This could include experiences in the laboratory that lead to an understanding of such devices as electric circuits, the telegraph and telephone, electric motors and dynamos and magnetos, the ignition system of an automobile, uses of electricity in heating and lighting, house wiring, radio transmission and reception, including the operation of the tube, the radio-frequency circuits, the audio-frequency circuits and transistors.

(ii) Automotive mechanics. The power system, the electrical system, the fuel exhaust system, the braking system, the power transmission system, the lubricating system, safety and care in the use of the automobile.

(iii) Pre-flight aviation.
(iv) Conditions and survival in the border mountains
(v) The production and processing of foods
(vi) Safety and first-aid.
(vii) The prevention and control of disease

Certainly much of the enthusiasm of the boys and girls to make contribution to national defence could be well channelled into such practical courses as the ones I have mentioned above But these courses should not take the place of the more basic courses of the curriculum. They should be in addition to the regular curriculum. Let us consider now, the nature of science. This is the science that should be taught in the basic curriculum

The Nature of Science

Many schools emphasize science as a matter of *learning about* the physical world and about the living creatures in it. While this type of approach has its place, far more emphasis should be given to science as an *intellectual activity* than is at present. This intellectual activity should be a part of almost every science-related experience the students have. They should behave as scientists even be scientists as they observe and interpret natural phenomena.

Conant has defined science 'as that portion of the accumulated knowledge in which concepts develop from observations and experiments, which concepts lead to further observations and experiments'. Science is what scientists do Science is *not* the phenomena ; science is the explanation of the phenomena.

Science is founded on a belief in a universal order in nature, an order man can understand. Newton's Law of Gravitation, for example, is a way of accurately explaining a wide number of related phenomena from the results of careful observations, experiments and calculations. The moon is kept from flying off into space by the same force that pulls the apple to the ground. If Newton's calculations were correct, then he could predict the rate at which the apple would be pulled to the earth. This he did. Because the scientist perceives nature as logically ordered, motions so vastly different in magnitude as the fall of the apple, or the circling of the moon around the earth, can be accounted for by an exact theory. Bridgman refers to this conviction that nature is explainable as one of the most significant breakthroughs in the history of science.

The explanations which constitute science are based upon facts, but we must not mix facts with suppositions ; certainties with conjectures. Young people should have experience in distinguishing facts from the explanations of these facts. Experiments are used to get facts to verify or to reject the predictions made in accounting for what happens.

The evidence from research indicates that more and more children reason as adults do. This being the case, we must so plan our science programmes that children have experience in explaining natural phenomena as well as in learning facts about science. Science becomes alive when the boys and girls have a chance to think scientifically and to experiment; when they construct a model to explain something, when they conduct an experiment to check on a prediction they have made.

The fun of science is in achievement, in gaining a new sense of understanding. This understanding can be gained by trying to explain something, or in trying to find out something

How to Teach Science so that Students Account for Phenomena

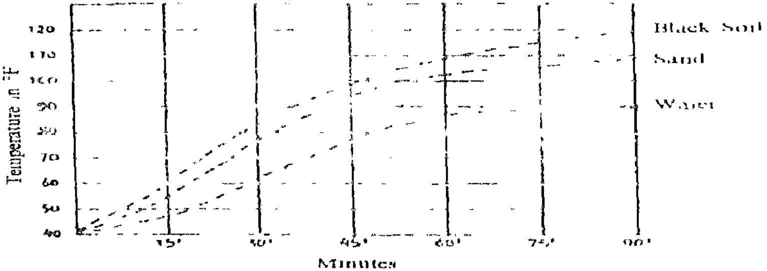
Suppose, for example, that students are interested in the formation of clouds. How do clouds form ? Do they form like dew ? Dew forms when water vapor condenses on a cold object. The conditions for the formation of dew are moist air, a drop in temperature and something cold for the water vapor to condense on. If clouds form like dew, then we could make a cloud in a bottle. (Demonstration) We could have the bottle filled with moist air, we could cool the temperature and a cloud should form. How can we cool the air in the bottle ? You know that air warms as it is compressed and cools as it expands. Perhaps we could warm the air by blowing in the bottle, and then cool the air by letting it expand. Let's try it No cloud forms. What is wrong with our theory ? Perhaps there must be some dust in the air on which the water vapor can condense. So we will put in some smoke to serve as dust particles. And when we try warming and cooling the air this time a cloud forms. So we have confidence in our knowledge of how a cloud is formed. We have a bit of *tested* dependable knowledge.

Mathematics can be used to make the findings of science more precise. Suppose, for example, teachers want to help their pupils understand how the atmosphere is warmed. According to one theory, the earth is warmed by the light of the sun, and then the earth radiates energy as radiant heat energy, which radiant heat energy warms the air just above the earth's surface. This theory can be tested. The air over land warms faster in the day time than the air over the ocean It must be that the land surface warms faster than the water surface. If this is true, we would be able to test this prediction. We can put equal samples of dark soil, light sand, and water in a refrigerator overnight, then place them in the sun and see if the soil and the sand warm faster than the water (Projection of slides).

CHANGE OF TEMPERATURE OF WATER, SAND AND SOIL WHEN PLACED IN SUN

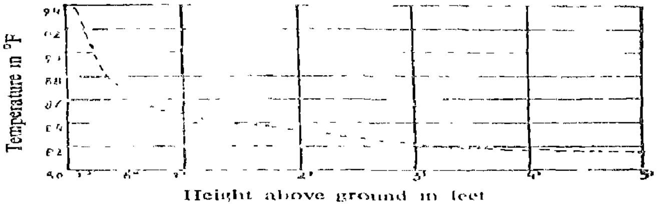
Time in minutes	*Water*	*Sand*	*Black soil*
90	90 F	109 F	118 F
75	80	104	118
60	88	102	108
45	78	96	99
30	62	75	84
15	48	55	61
0	40	40	40

RATES AT WHICH WATER, SAND AND SOIL ARE WARMED IN SUNSHINE



When we do this we find that the dark soil warms fastest, the light sand next and the water the slowest. So our experiment verifies our prediction. A second prediction can then be made, namely, that if the air is warmed by radiant heat from the earth, then the air near the earth's surface should be warmed more than that a little way up, and we should be able to measure this difference in temperature by placing thermometers at different levels. When we do this we find our prediction is verified. The air near the earth is warmer than it is a little way above as is shown in the following graph :

TEMPERATURE AT NOON IN THE SUN
TEMPERATURES ARE AT VARIOUS HEIGHTS FROM THE GROUND

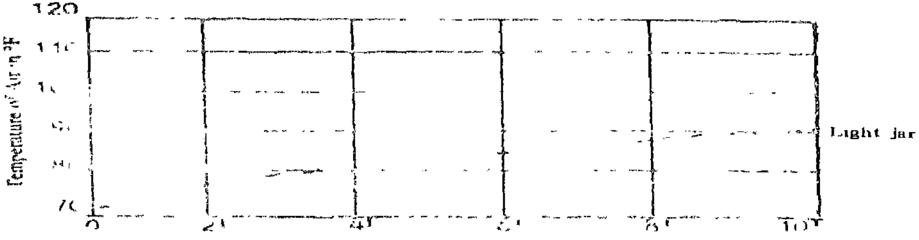


Again we have confidence in our explanation for we have verified it by experiment. Still a third prediction can be made, namely, that if we shine light on a jar representing a room, and have the backside painted dark, the dark colour will absorb light energy, become warmed and the air inside the jar will then be warmed considerably—much more than a similar jar without any black paint. When we try out this experiment we find our predictions also to be correct, as is shown in the following table and graph. So we build confidence in our explanation of this natural phenomenon.

COMPARISON OF RATES AT WHICH DARK AND LIGHT JARS ARE WARMED IN SUN

Time in minutes	*Temperature of air in light jar*	*Temperature of air in dark jar*
10	90	112
8	87	106
6	84	100
4	80	90
2	76	81
0	72°F	72°F

COMPARISON OF RATES AT WHICH DARK AND LIGHT JARS OF AIR ARE WARMED IN SUN



Time in Minutes

Even in connection with applied science, students can devise experiments to test predictions and account for the operation of equipment. For example, an experiment can be devised to test the effectiveness of different insulating materials The above are but a few of the many simple experiments that can be done to give students experience in accounting for the things they observe in their natural environment.

In teaching so as to involve students in guessing explanations and then in planning experiments to check on the consequences of these predictions it is helpful to think in terms of *if-then* propositions. *If* this is true, *then* this should happen. Then experiments can be devised to see if the 'then' happens. The 'then' is the test of the validity of the predictions. This can be illustrated in many ways, for example, by studying the conditions necessary for a fire, and predicting how fires should be extinguished. A candle may be extinguished by covering with a test tube (suffocation), by blowing it (cooling below kindling temperature) or by adding a little water to freeze the wax (removing the fuel). Likewise students might consider how to extinguish a hot fat fire, and predict that water would spread it rather than extinguish it. If this is so then a little bit of wax could be heated over a candle in a small spoon till it catches on fire. If a little water (a few drops) are added the water should spread the fire. When tried out this is exactly what happens---for the water settles to the bottom *k*, turns to steam and blows the burning fat out into the air. The verification of the prediction gives confidence in the knowledge one has about how fires are extinguished.

In conclusion, may I say that everyone needs science ; one needs it in one's daily life ; society needs technicians and scientists ; statesmen and politicians need it to make wise decisions ; and finally the man on the street needs it to make wise decisions as to who should serve a leadership role in his government.

Science can be made much more practical and hence become more effective in our daily lives and in our defence effort.

To a considerable extent each of us takes on the way of the scientist, - a way that makes us live more richly and more effectively and enables us to make a more significant contribution to the society in which we live.

In teaching science we must arrange a situation so that boys and girls do carry on experiments, they use a scientific approach in coming to sound conclusions, and they understand the conclusions that they have drawn for they have tested the consequences of their predictions.

TEACHING TECHNIQUES IN GENERAL SCIENCE

The science teachers in the R. M. Trivedi New Education High School, Ahmedabad, wanted to see how vital a science programme could be made under the present examination system, and how the State syllabus could be enriched. This is a result of their study.

During the years 1958-1961 under a programme of school improvement, the Science Department experimented with certain innovations in teaching techniques in General Science, in standards VIII and IX. The major objectives did not stress on giving information to pupils, but they were directed to changes in the behaviour of pupils with emphasis on getting pupils to develop a scientific attitude.

Besides the general objectives outlined for the courses in each standard, the following specific objectives were formulated :

SPECIFIC OBJECTIVES OF TEACHING GENERAL SCIENCE IN STANDARDS VIII AND IX

1. To develop ability to apply scientific knowledge in everyday life.
2. To develop the following skills in pupils :
    - (a) Handling laboratory apparatus
    - (b) Handling instruments and appliances of everyday use
    - (c) Constructing scientific instruments, toys, etc.
    - (d) Improvising certain models
    - (e) Preserving instruments, models, objects, and scientific materials.
    - (f) Drawing charts, diagrams, and sketches.
    - (h) Preparing slides of scientific specimens, objects and processes
    - (i) Collecting data and organising data tables and graphs
    - (j) Presenting data in a scientific way.
3. To develop the ability of oral expression in using scientific terms, facts and principles, :
    - (a) Oral expression
    - (b) Oral description
    - (c) Oral discussion
    - (d) Oral narration
    - (e) Formulation and oral expression of questions, difficulties and problems.
4. To develop the ability to interpret scientific data in tabular, graphic or any other form.

5. To develop scientific interest
    - (a) Current development
    - (b) Reading scientific materials
    - (c) Visiting places of scientific interest
    - (d) Collecting scientific toys and scientific appliances.
6. Appreciation in science .
    - (a) Impact of science on living and social life
    - (b) Writing of different authors in science
    - (c) Lives and work of great scientists
    - (d) Beauty of nature.

NOTE : Most of these objectives will be common for standards VIII and IX However, the degree of complexity will increase with the growth of the pupil's achievement.

A reorganization of the present general science syllabus was made in terms of problem-centred science units related to the society from which the pupils came. The reorganization of the syllabus so worked out is given below.

STANDARD VIII

1 THE OCEAN OF AIR IN WHICH WE LIVE

Air, constituents of air, how air can be kept pure, effects of sunlight on air, ventilation, artificial and natural suffocation, artificial respiration, mountaineering, effects of reduced pressure on breathing, atmospheric pressure, its measurements, simple barometer, its construction and uses. Measurements of altitudes, combustion, burning of a candle, carbon-dioxide, preparation, properties and uses of combustion in the human body, exhaled air.

2. PENICILLIN—THE WONDER DRUG

Organs of breathing, elementary notions of pharynx, larynx and wind pipe, bronchi, lungs, study of respiratory system, respiratory ailments, cough and cold, bronchitis, pneumonia, penicillin—the wonder drug.

3. WHAT HAPPENS TO THE FOOD TAKEN BY THE BODY

Organs of digestion, teeth, tongue, gullet, stomach, intestines, liver, common ailments of digestion, laxatives.

4. HOW WASTE MATTER LEAVES OUR BODY

Excretion, organs of excretion, kidney and bladder, skin, its structure and function, skin diseases, ring worm, scabies, small-pox, measles, chicken-pox, their prevention

5. HOW WE COOK OUR DAILY FOOD

Food—raw and cooked—when cooking is necessary, nutrition problems, fats and carbohydrates, and elementary notions of dietetics. How heat travels, conduction, convection, radiation, everyday application of the principles of transference, thermos flask, Davy's safety lamp, polished surfaces, expansion of solids, liquids and gases when heated, practical applications.

6. PLANTS THAT PREPARE FOOD FOR US

Soil as a store house of plant food, types of soils, natural and artificial manures, night soil, grow more food, method of growing staple food such as rice, wheat, bajra, jowar, maize, onions, and potatoes, local vegetables and kitchen gardening.

7. GOOD HEALTH FOR YOU AND YOUR COMMUNITY

Personal hygiene, rest, sleep, work, exercise, cleanliness of the nose, hair, mouth, nails and sex organs, selection of proper clothing, habit of personal cleanliness.

8. HOW WE AND ANIMALS MOVE

A broad study of skeleton as a whole including bones, joints, muscles, voluntary and involuntary muscles, biceps and triceps, diaphragm, movements of snake, earthworm, lizard, scorpion, ants, bees and birds, fish and jelly-fish

9. CAMERA AS A MAN-MADE EYE

How light travels, pinhole camera, rectilinear propagation of light, principles of reflection, multiple images, mirrors inclined at 90° and 72° kaleidoscope, simple mirror, periscope.

10. HOW NAVIGATORS LOCATE DIRECTION

Magnet as an aid for navigation, fixing directions, natural and artificial magnets, lines of force, magnetic poles, laws of attraction and repulsion.

STANDARD IX

1 HOW WE GET OUR DRINKING WATER

Purification of water, decantation, filteration, boiling and distillation, use of disinfectants, such as chlorine, bleaching powder, alum, potassium permangnate, water borne diseases such as cholera, typhoid, dysentery, their prevention and cure.

Boiling, effects of dissolved substances and pressure, papin's digester, domestic cookers, evaporation and cooling, earthen vessels as water coolers. Heat and temperature, construction and uses of different kinds of thermometers.

Effect of salt on freezing point, ice cream.

Hard and soft water causes, lather, soap, effects of hard and soft water on washing, softening of water, what living things are made of—amoeba, repair and growth in living things.

Effects of evaporation in nature, condensation, formation of mist, fog, dew, and rain, humidity, wet and dry bulb thermometer, effects of moisture on iron, iron rust, galvanised and tinned iron and other methods of preventing iron from rusting, Archimedes' principle, upward thrust.

2 THE MILK THAT WE USE IN OUR DAILY FOOD

Food, samples of vegetarian and non-vegetarian balanced diets suitable for Indian climates. Build of the body and its relation to food. Food values of nitrogenous food, cereals, pulses, starches, green vegetables, fruits, nuts, milk and milk products ; cheese, ghee, butter, butter-milk, mineral salts, vitamins, spices, common drinks, healthy and harmful, food poisoning and tinning, use of lactometer, floating bodies

3. HOW THE WOUND GETS HEALED

Heart as a pump, heart beats, pulse, auricles, ventricles, valves, circulation of blood, main arteries, veins and blood capillaries, constituents of blood, red and white corpuscles, bleeding—its control, pressure points.

4. THE BICYCLE I RIDE ON

Wheel and its working, gearing and motion of wheels, friction, kinds of friction, their utility, advantages and disadvantages, lubrication to lessen friction, ball bearings, brakes, why tyres of wheels have rough surface, gravity and equilibrium, kinds of equilibrium. Necessary conditions to keep body in equilibrium. Elasticity—elastic substances, use of air as elastic substance in pneumatic types. Uses of spring as elastic substance in different vehicles. First law of motion

5 HOW SOUND IS PRODUCED

Difference between noise and musical sound, speed of sound in solid, liquid and gases. Intensity of sound, brain, its different parts and their working. Spinal cord and its working. Sensory nerves, motor nerves, nerve cells. Common reflexes. Reflection of sound and echoes

6 THE PRIMUS STOVE THAT COOKS OUR FOODS

The air we breathe, pressure, pumps, suction and compression, force pump, stove pump, siphon and flush tanks

7 HOW WE TELL TIME

The clock, pendulum, relation between length and period of oscillation. The study of movements of constellations like the Great Bear, Cassiopeia and planets like Mars, Jupiter, and Venus.

8. THE CINEMA THAT ENTERTAINS US

How light travels, bending of light and refraction. Effects of refraction, mirrors and lens. Persistance of vision.

9 OUR MODERN MEANS OF CONVEYANCE

Sources of power, steam and petrol, locomotives, motorcars and aeroplanes.

NOW, HOW WELL WERE OBJECTIVES ACHIEVED ?

To assess the effectiveness of the new approach, a careful count was made of the number of journals and books used, besides the tests. Under the guidance of an evaluation officer, unit-wise achievement tests were given. Places visited by pupils, models prepared, and other resources used were also noted.

A summary of results from the pilot project in one unit, *How We Tell Our Time*, in standard IX, follows :

SUMMARY OF RESULTS

(a) The reading habit of the experimental group was clearly observable. The number of books on general science and journals referred to by each group during the course of the experiment was as follows :

Group	*Number of pupils*	*Total number of books etc read by each group*
A	15	1 Textbook — 23
B	14	1 Textbook — 20
C	15	1 Textbook — 20
Control Group	15	1 Textbook - - Nil

(The class from which the control group was selected was formed from every third pupil from amongst the ranks assigned from the previous examination)

The above figures show that the pupils of the experimental group showed interest in reading books and journals on general science.

(b) The pupils of all the groups (including the control group) were administered the same test at the end of the pilot project. The test was assigned 45 marks in all, having one score for each item. The answer papers of the pupils were assessed accordingly by one examiner.

The scores of both the control (15 pupils) as well as the experimental group (44 pupils) were combined for statistical analysis

Scores	*Frequency*
35 to 39	10
30 to 34	24
25 to 29	17
20 to 24	6
15 to 19	2
	N – 59

The whole group was then divided into three parts Those below the first quartile were given Grade C. Those between the first and third quartiles were given Grade B. Those above the third quartile were given Grade A

The following table shows the results of both the control and the experimental groups in percentages :

Group	*Grade A*	*Grade B*	*Grade C*
Control Group	0%	46.6%	53.4%
Experimental Group	22.7%	70.5%	6 8%

The following tables show the results of each group.

Group A

Scores	*Frequency*
35 to 39	7
30 to 34	4
25 to 29	4
20 to 24	
15 to 19	—
	N —15

	Grade A	*Grade B*	*Grade C*
No. of pupils	7	8	0
Percentage	46.6%	53.4%	0%

Group B

Scores	*Frequency*
35 to 39	3
30 to 34	5
25 to 29	4
20 to 24	
15 to 19	2
	N 14

	Grade A	*Grade B*	*Grade C*
No. of pupils	1	14	0
Percentage	6.6%	93.4%	0%

Control Group

Scores	*Frequency*
35 to 39	
30 to 34	3
25 to 29	6
20 to 24	6
15 to 19	
	N 15

	Grade A	*Grade B*	*Grade C*
No. of pupils	0	7	8
Percentage	0%	46.6%	53.4%

The above statistics show definite improvement in performance of the class in the experimental groups. It is due to the methods employed by the teachers in charge of experimental group

(c) The pupils of the experimental groups spent on an average about two hours per week over and above the scheduled hours in the time-table. This was arranged at the initiative of the pupils. The control group did not spend any extra time over and above the scheduled hours in the time-table. The pupils of the control group spent a few hours of the school to observe and study the constellations, stars, etc.

(d) Suggestions regarding the types of models to be prepared, times for meeting after the school hours, etc., were made by the experimental group. No such suggestions were made by the pupils of the control group. This is indicative of the degree of initiative shown by the experimental group.

(e) Differences among the sub-groups were not widely noted.

(f) The pupils of different experimental groups discussed various sub-topics of the project. During the discussions it was noticed that the pupils were eager to contribute, to make some suggestions, to understand the speaker, etc.

(g) Comparing the initiative of the Groups A and B, and Group C, it was found that there was less initiative in the matter of suggestions, etc. on the part of the pupils in Group C, where two teachers were in charge, than those of the Groups A and B, where one teacher was in charge.

CONCLUSION

(i) *Experience of the pupils*

(a) The pupils found themselves quite at home with their work because they could work at their own pace.
(b) This approach to teaching was found by them more helpful in their learning process.
(c) They found a lot of freedom in their work

(ii) *Experiences of teacher in charge of the pilot project*

(a) The pupils became regular in their home assignment and in other activities after this method was adopted.
(b) The pupils were found interested in this project even though the time selected was just before the annual examination.
(c) The pupils had a variety of learning activities which provided a scope for selecting their work according to their aptitudes and abilities, e.g. the pupils having a good hand writing and proficient in art undertook the work of writing and drawing. Pupil having the facilities for preparing certain iron spare parts or having some training of carpentry from his father helped his sub-group in preparing the wooden parts of different models.
(d) The group discussion method employed during this project was found to be successful in promoting self-learning and in materialising the objectives laid down in the plan.
(e) The experimental work which supplemented the group discussion method was also found successful in developing the different skills mentioned in the plan.

(iii) *Observations of pupils' achievements*

(a) The pupils read and referred to useful books and magazines and other materials.

(b) An attempt at self-learning was visible.
(c) The pupils' capacity to organise materials collected and to use them for solving problems was noticed.
(d) The pupils were found co-operative to the teachers as well as among themselves.
(e) The pupils' general achievement in comparison to the control group was decidedly superior.

CASTING ANIMAL TRACKS IS ENTERING THE WORLD OF WILD ANIMALS

N. SUTARIA

Sponsor, Science Club, Shree Vidyanagar High School
Usmanpura, Ahmedabad

If you are curious, and like to create things, and collect, then casting animal-tracks will take you to the amazing world of animals.

A plaster cast is easy to make. All the materials you need are : a packet of plaster of paris or dental plaster ; a bowl ; a spoon ; a stick ; thick paper ; paper clips ; used tooth-brushes ; and two or three paint-brushes.

As the actual tracks rarely have perfect details, tracks for casting found in monsoon will be better than in other seasons. However, tracks can be found all the year round in sandy beaches. Easiest to cast are those in mud or clay ; most difficult are in dry sand. Best places to look for them are on trails along stream-banks, and the woods after a rain. Even a zoo can be a good place for casting, provided the authorities help you.

The desire for writing about our collections was not so intense, till the plaster mould of a Himalayan bear's footprint was obtained by my young companions. I now believe that this plaster mould in itself is going to become an event in the sense that it will excite the world-wide imagination of many, those who have been taking keen interest in the Himalayan Snow-man. We have heard quite a lot, and there exist many fables about him. This strange name, however, came to our ears first, in the year 1933, through a well-known mountaineer Frank Sidney Smith who claimed to have seen strange footprints on the snow-covered peaks of the Himalayas beyond an altitude of 27,000 feet. Eric Shipton was another person who not only found the foot-prints, but also collected lot of information—of course based on fables—from the 'Lamas'. He was then appointed to investigate these beliefs, by obtaining some evidences if he could when he was sent again to the Himalayas. All that can be concluded from what Eric observed is that the foot-prints were exceptionally large and that they resembled the human foot-print. He could not, however, procure any part, either living or dead, of the Snow-man, which could strengthen the belief. Men of many expeditions have made mention of the Snow-man, but have not seen one, except perhaps as an illusion when they were in terror.

Vidal, perhaps the first known mountaineer, wrote a book in 1899, wherein he claims to have found very large foot-prints on the way to Tibet, and he believed them to be the foot-prints of a Snow-man about whom he had heard fables.

A few years ago all those who had something to say on the Snow-man were invited to England by the London Zoological Society. Persons who assembled there from various corners of the world were divided into two groups. One of the two groups believed that the facts about the Snow-man were all rubbish and imaginary, and were based only on fables. They also said that the foot-prints which were presented there in the form of photographs as an evidence of the Snow-man's existence, could possibly be those of the Himalayan bear.

No one so far has ever obtained the plaster mould of any such foot-marks, and I can claim that we are the first to possess them, since no one has produced any such reference anywhere, either by an individual or an expedition, so far as the Snow man's foot-prints are concerned. The description of the photographic foot-print, given by Eric Shipton is exactly the same as the actual plaster mould we have recently obtained of a Himalayan bear, (Himalayan Black Bear -*Selenarctos Thibe Tanus*) four years old

We strongly believe that the Snow-man never existed and the large foot-prints obtained during all the expeditions must have been those of a bear.

When this project was undertaken by our science club, we never had any intention other than that of making our boys good naturalists, and to make them take interest in the study of wild animal psychology and their curious habits. We have so far collected more than thirty plaster moulds of various wild and tame animals, besides that of a bear. Among our collection of these moulds, the plaster-cast of the only white tiger in the world, Mohan's son Sultan's foot-print is unique.

I selected a team of four very active and intelligent members from our science club for the purpose. Most of the casts we possess are of the foot-marks of animals from Kankaria Zoo, taken with the kind co-operation of the zoo Superintendent, Mr. Rubin David.

METHOD OF CASTING

Step 1. After finding a track, carefully brush away twigs, small stones, and excess dirt found in its immediate vicinity

Step 2. Then use a cardboard strip 1½ inches wide, to surround the track. Fasten strip with paper clip to form a sort of a dam. Push down this dam lightly into earth.

Step 3 Mix plaster of paris to a consistency of thick cream. (Let the plaster be put into water and not water into plaster) Pour cream slowly over track.

Step 4 After the plaster hardens in about 10 minutes, lift out the panel cardboard Then paint after several days to give a finishing touch.

These plaster casts can be turned into interesting wall decorations.

CLASSROOM EXPERIMENTS

PERMANENT SCIENCE CHARTS WITH PLASTIC TUBES

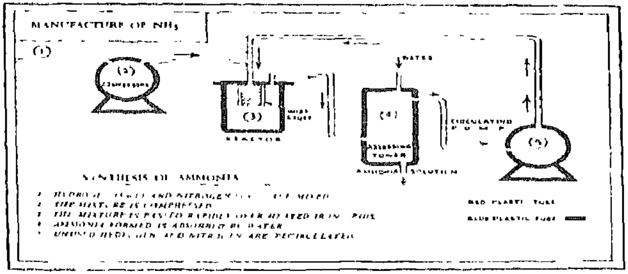
Charts are usually made with Indian ink on drawing paper. Colours are also used. The charts are pasted on to cardboards and hung on the wall. There are a few drawbacks in the charts made in this usual way If the cardboard is not thick enough, the charts bend inwards. Of course, this defect can be remedied by nailing the four corners of the charts to the wall. The lines cannot be drawn thick enough to make the details of the chart visible from a distance.

Charts prepared by using plastic tubes and plywood do not have these drawbacks. Further, they can be hung artistically on the walls. They can be cleaned with a wet cloth. Besides, the charts are more durable than drawing paper charts.

Material and Methods

Plywood from tea chests, plastic tubes of various colours (red, blue and green), coloured varnish paper for background, 1¼ cm. wire nails or oraldite to hold the plastic tubes in their places, are the materials required.

The two sides of a tea chest are placed together and secured behind with strips of wood so as to form a panel of wood about a metre long and 50 cm wide. The surface of the panel is made smooth with sand paper. Coloured varnish paper (usually yellow or red) is pasted on this to form a background. Coloured paper slips are also pasted to form a border of about 3 cm wide Then the chart is drawn on the panel with a



pencil. Plastic tubes of suitable colour are nailed in position giving a 3D-effect to the chart. The various parts are labelled and numbered. A descriptive caption is added explaining the various steps of the figure with reference to the numbers put on the chart. The complete chart is covered with a cellophane sheet and secured with nails on the underside. Then two hooks are fixed on the side of the chart. Now, it can be hung on the wall at a suitable place.

Some very instructive charts can be made this way to attract and hold the attention of students. *Understanding Science*, an encyclopaedia in pictures has very instructive diagrams which could be made into charts and used in the schools.

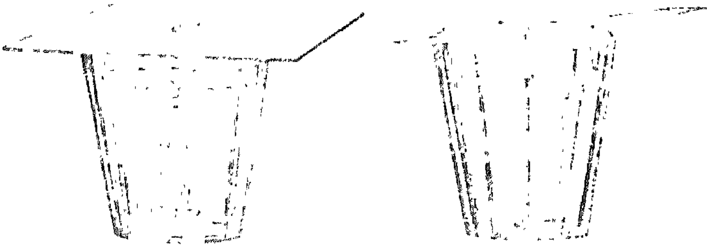
P. S. V. Rao

FORMATION OF CRYSTALS*

Crystallization is a method by which a substance can be purified. When crystals are formed, they usually leave behind any impurities that were in the original substance. When the saturated solution of any substance is allowed to cool the substance dissolved separates out as crystals. The more slowly crystals are formed the larger they will be.

Salt Crystals

Fill a glass jar with hot water. Add salt as long as it continues to dissolve. Have ready a piece of cardboard from which a piece of string is hanging. The string may be threaded through holes punched in the



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* From *Discovering Chemistry* by Elizabeth K. Cooper, Harcourt Brace & Company, 1959, pp. 170-73.

middle of the cardboard. The string should be just long enough to reach the bottom of the jar Weight it at the end by tying to it a small piece of metal such as a bolt, screw or nail. Drop the string into the hot solution. Cover the jar with the cardboard and place the jar in a quiet, warm place where it will cool very gradually Watch the experiment as salt crystals form on the string.

After a few days, you should have a string of large crystals, which you can lift out of the jar.

Rock Candy

Large crystals of sugar can also be formed in the same way.

In a clean pan, boil three-fourths of a cupful of water. While the water is boiling gently, stir in granulated sugar, little by little till no more will dissolve. It will probably take more than two cupfuls of sugar to make a fully saturated solution.

Pour the hot solution into a glass tumbler. A silver spoon placed in the tumbler while the liquid is being poured will absorb enough heat to keep the glass from cracking, then remove the spoon. While the solution is still hot lay across the tumbler a pencil to which you have tied a piece of clean cotton string. Hang the string in the solution. Weight the bottom of the string with a small, clean metal object.

Set the tumbler in a quiet, warm place. The solutions will cool and then evaporate slowly leaving behind large crystals of sugar hanging on the string. When the crystals have stopped growing (usually in two or three days), the rock candy is ready to be eaten or to be added to your collection of home-grown crystals

Elizabeth K. Cooper

CHEMICAL TREES

The Lead Tree

Materials required : Bottle, lead acetate, a piece of zinc.

Method : Dissolve a quarter ounce of lead acetate in half a pint of water. If the solution is cloudy, let it stand till it is clear, or filter it or add a little acetic acid. Suspend a piece of zinc, so that it projects into the upper part of the liquid (Fig. *a*), and leave the bottle where it will not have to be moved. Fern-like crystals of metallic lead gradually grow out from this zinc The last formed are usually the most beautiful

The Silver Tree

Materials required : Small clean glass bottle and cork, silver nitrate (½ gm.) distilled water, piece of copper wire.

Method : Dissolve a small quantity of silver nitrate, about ½ gm. in an ounce of distilled water. Pour into a small clean glass bottle or a test-tube. Push a short piece of clean copper wire into the cork and let it dip into the liquid. A beautiful gleaming pendant of crystals of silver grows down from the copper wire (Fig. *b*).

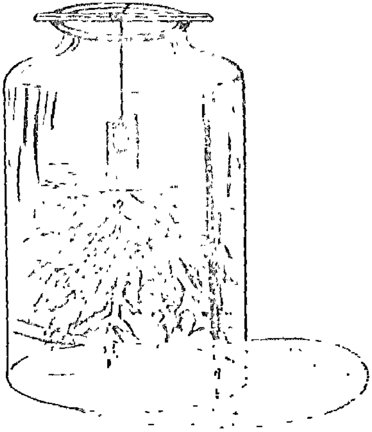

Fig. (*a*) Lead Tree

Fig (*b*) Silver Tree

Explanation : The chemical reactions are simply the replacement of one metal by the other.

(1) $Zn + Pb(C_2H_3O_3)_2 = Zn(C_2H_3O_2)_2 + Pb$, i.e., Zinc + Lead acetate = Zinc acetate + Lead.

(2) $Cu + 2 AgNo_3 = Cu(NO_3)_2 + 2 Ag$, i.e., Copper + Silver nitrate = Copper nitrate + Silver.

LABORATORY HINTS

Labelling of Laboratory Reagent Bottles

The following method is at once cheap, simple and effective for all ordinary reagents, although, naturally, the labels will be affected after a time by strong acids or caustic alkalies.

The best results are obtained with labels printed (or written) on fairly thin paper. Attach by gum in the usual way, taking particular care that no air bubbles are left under the paper, and allow to dry.

Next melt some paraffin wax in an evaporating dish, heating until a faint smoke just begins to form. Avoid heating beyond this point, or the wax will ignite.

Apply the molten wax to the label with a flat bristle brush. Pass a Bunsen flame quickly over the waxed surface, and while the wax is still warm, wipe away any surplus from the glass with a soft cloth, leaving, however, a narrow margin of wax all around the label.

TREATMENT OF BENCH TOPS*

The best method of preserving the wood tops of laboratory benches is by frequent treatment with raw linseed oil. The surface should first be scrubbed with soap and water and allowed to dry ; the oil should then be well rubbed in and allowed to dry thoroughly, after which further applications may be made until the wood will absorb no more. The object of small intermittent applications is to enable the oil to oxidize and thus solidify into a resin ; if too much oil is applied at once, oxidation is prevented and the surface remains sticky. If necessary, the oil may be thinned with a little turpentine, which will evaporate

Alternative treatment consists of (a) rubbing in bees-wax softened with turpentine, or one of the proprietary floor polishes of like composition : (b) ironing in paraffin wax, or rubbing in a solution of the wax in petrol, xylene or other solvent ; and (*c*) treatment with aniline black.

Paraffin wax has a low melting point, and unless completely absorbed, becomes a nuisance by melting when hot bodies are placed on the bench. Aniline black, though very resistant to acids, involves an almost entire loss of light by reflection and forms a very sombre background for work.

Alan E. Manby

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* From *Science Masters' Book*, Part II, Series I, John Murray, London.

PLAN OF A TEACHING UNIT—3

K. L. KHURANA

Department of Science Education, N. I. E., Delhi

An outline of a teaching unit based on the Unit approach to teaching science is suggested below to help teachers in preparing their lessons on topics related to geology—an area introduced recently in the general science syllabus for schools in all the States.

Topic : Rocks and Minerals (Class VII)

I. INTRODUCTION

Display charts giving facts and figures about the interior of the earth.

Discuss the preliminary ideas to form a background for the unit and to ensure pupil participation :

(a) How old is the Earth ?
(b) What changes has the Earth gone through ?
(c) How do scientists picture the past ?
(d) Are the crust and interior of the Earth the same ?
(e) What types of rocks are found and where ?
(f) What are rocks composed of ?
(g) How do rocks appear to have been formed ?

II. QUESTIONS AND PROBLEMS

Major questions and problems to be answered are :

1. In what ways are rocks different ?
2. How are rocks classified ?
3. What are minerals ? How can they be identified ?
4. How are sediments deposited and changed into sedimentary rocks ?
5. How are igneous rocks formed ?
6. How are metamorphic rocks formed ?

III. ACTIVITIES AND EXPERIENCES TO BE USED IN SOLVING PROBLEMS

1. *Rocks have different minerals and textures.*

Look for regularly shaped crystals in coarse igneous or metamorphic rocks. Select some crystalline rocks and pound them one by one, wrapped in a piece of cloth placed on a hard surface and beaten. Use hand lens to examine the rock fragments and try to determine the number of easily

Fig. 1. A diagram of rock being pounded, wrapped in a piece of cloth

observable minerals each contains. Discuss why the hardness, texture and colour differ with rocks. Some of the minerals may be present in rocks in such small quantities that their grains can only be seen with a hand lens and sometimes with a microscope.

Notice that the inner surface of fragments of the rocks do not look the same as the surface of the rocks. Summarise the factors that cause changes in the outer surface of rocks, (e.g., sun, temperature, water, snow, wind, and plants)

2. *Rocks are classified according to their origin*

Examine a set of identified rock samples and observe the common structure with most of the different rock samples.

Study carefully a number of rock samples with a layered structure (like limestone, shale, dolomite). Notice the rough and gritty surface of samples like sandstone. Deduce that such rocks are composed of small grains of sand cemented together. Notice that some samples like shale which feel smooth are composed of fine particles. Conclude that such rocks appear to be deposited as sediments, usually flat and layered. The sediments may be composed of highly powdered materials (clay and silt), or of grains from harder materials (sand and gravel).

Next investigate a few samples of rocks that are massive and are made up of crystals (like granite, diorite, basalt, felsite, obsidian). Observe the difference in size of crystals and surfaces Conclude that such rocks appear to have been formed from hot liquid lava or magma. Those with tiny crystals or with glossy surface and no observable crystals (obsidian, basalt, felsite and the like) are believed to have cooled quickly at the surface of the earth, while those with large crystals (like granite, diorite) are believed to have cooled slowly deep in the earth.

Similarly examine some of the rock samples which are crystalline, foliose, banded or massive in structure (slates, schists, gneisses, quartzites, marble, and the like). Conclude that such rocks appear to have been metamorphosed (greatly changed by heat and pressure) form of the pre-existing rocks ; the particles in such rocks are compressed more than in the rocks from which they were formed (quartzite--metamorphosed sandstone, marble - metamorphosed limestone).

3. *Some of the common minerals can be identified easily*

Try to recognise an identified set of the common mineral specimens with the help of Table A and information from books on geology. For each mineral in your rock collection find out such information as its chemical composition, lustre, hardness, specific gravity, colour in which it occurs or colour of the streak it makes on the unglazed back of a tile, and other interesting facts, if any.

Select and develop experiences that will help the pupils understand the chemical composition of minerals. Also help to develop understanding of such words as glassy, dull, metallic, and greasy to describe the minerals in the school's rock collection.

Find the hardness of a mineral making use of a standard set of minerals with a fixed hardness 1-9 (Moh's Scale). In the absence of the set of minerals, improvise substitutes as shown in Table B. To save time in testing hardness of minerals, scratch the minerals to be identified with quartz or a steel file (since many common minerals have a hardness 7 or less) Examine carefully the scratch on the mineral and rub your fingers over it to make sure that it is a distinct scratch. If the identified mineral is scratched by quartz or steel file, its hardness is less than 7 or 6.5 and *vice versa.* To locate the hardness of a softer mineral, repeat the process with less hard minerals of the standard set or their substitutes.

Encourage some of the pupils to determine the specific gravity of a few samples of pure minerals (like quartz with specific gravity 2.6, calcite

TABLE A. KEY FOR THE IDENTIFICATION OF SOME COMMON MINERALS

Name	*Colour*	*Distinguishing Features*	*Lustre*	*Hardness*	*Streak*	*Specific gravity*
Calcite	Colourless, white and variously tinted	Effervesces in cold dilute HCl; objects viewed through clear crystals appear double; stalactites and stalagmites in limestone caves are non-crystalline.	Glassy to dull	3	White	2.7
Chert or Flint	White to grey to black	Tends to splinter and fracture like glass; irregular, massive.	Dull	7	White	2.6
Dolomite	Colourless, white and variously tinted	Powdered mineral effervesces in warm dilute HCl; splits in cubes; occurs in crystals or grained mass	Glassy to pearly	3.5-4.0	White	2.8
Graphite	Steel-grey to iron-black	Feels greasy; soils finger; occurs in flakes, scales, or veins; flexible but stays bent; not elastic like mica.	Metallic	1	Grey to black	2.3
Garnet	Colourless, white, yellow, red, brown, green, black	Fractures unevenly; occurs in twelve, twenty-four and unequal four-sided crystals	Glassy	7-7.5	White	3.5-4.3
Gypsum	Colourless, white	Fingernail scratches it; occurs in granular and fibrous masses and in flexible but not elastic sheets	Glassy, pearly on smooth faces	2	White, grey	2.3
Mica	Dark-brown or black	Occurs in flexible and elastic sheets; splits in thin smoky-coloured, horizontal sheets.	Glassy	2.5-3	White to brown	2.8-3.4
Quartz	Colourless, white, smoky, rose, grey	Six-sided crystals; fractures like glass	Glassy to greasy	7	White	2.6
Hornblende	Black, dark-green or dark brown	Occurs in slender, six-sided crystals, in grains and masses	Glassy	5.5		3.2

with 2.7, and mica with 2.8 to 3.0) by ordinary methods

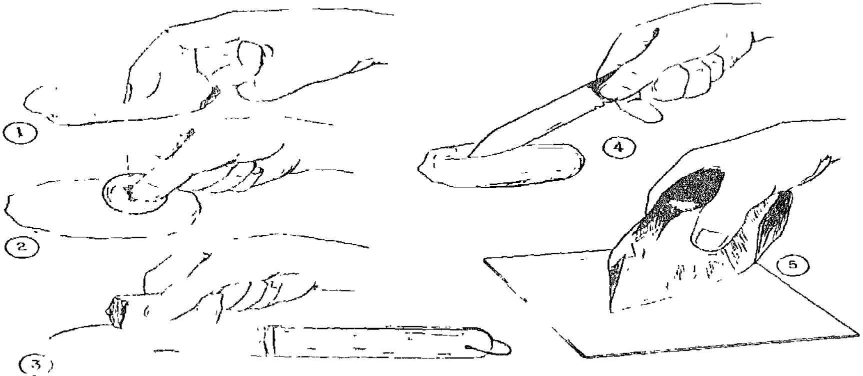

Fig 2 Some processes for finding hardness of minerals.

1. Scratching with finger-nail
2. Scratching with copper penny
3. Scratching knife blade
4. Scratching with knife blade
5. Scratching glass

*TABLE B. SCALE OF HARDNESS FOR MINERALS

Moh's Scale		*Common Substitutes*	
Talc	1		
Gypsum	2	Finger-nail	1 to 2.5
Calcite	3	Copper penny	3
Fluorite	4		
Apatite	5	Knife blade or glass	5.5
Feldspar	6	Steel File	6.5
Quartz	7		
Topaz	8		
Corundum	9		

* In a complete set, a tenth mineral, Diamond, with hardness 10 is included.

Observe the colour of a number of identified minerals and conclude that many minerals exist in several colours (While the colour of a mineral may vary, its streak obtained by drawing the mineral over a sheet of unglazed porcelain, is fairly uniform. Streak refers to the colour of the fine powder of the mineral). Next investigate the streaks of some of the minerals If a streak is dark and heavy, blow on it. (A thin layer of powder shows colour more distinctly than a thick layer.)

Report briefly on the elaborate tests and techniques performed by the geologists to identify minerals by their chemical composition, their reaction to special radiations (ultraviolet light), and their characteristic form in breaking (fracture) and splitting (cleavage)

4 *Sediments are deposited by natural forces, most sedimentary rocks were formed by the consolidation of sediments deposited in water.*

Discuss the forces of running water, gravity, ice and wind in causing sediments to move from one place to another Raise the problem—why some sedimentary rocks are composed of larger sediments than others. (The greater the force the larger the size and weight of the particles deposited.)

You can demonstrate how sediments are sorted as they are deposited in water by mixing an assortment of sediments like sand, silt and clay with water in a glass jar. Observe the settling of sediments. Conclude that the finer sediments remain suspended much longer than the coarser ones. Next add water glass (also known as silica which can be bought at a drug store) to the assorted sediments and let the jar stay undisturbed. (Silicates present in ground water cement together the sediments in many sedimentary rocks) Break the glass jar to examine the sedimentary rock formation.

5. *Igneous rocks were formed from molten mixtures*

(a) Toy wooden blocks, some wheat flour paste, a ramming rod, and two boards can be used to demonstrate why magmas flow away from the ocean and rise up the cavities and outward into the surrounding land masses. The pupils must understand what the materials and forces used in the model represent. Stack the blocks on the floor in one corner of the classroom. Insert between the blocks some wheat flour paste put in a small thick cloth bag with its mouth partly open. Ask one pupil to hold the board A, two for holding board B, and four or five to press hard the ramming rod. Remove the blocks one by one and find out what happened to the paste. (The paste representing magma should have been forced upward and may have reached the surface of the top blocks, toy blocks

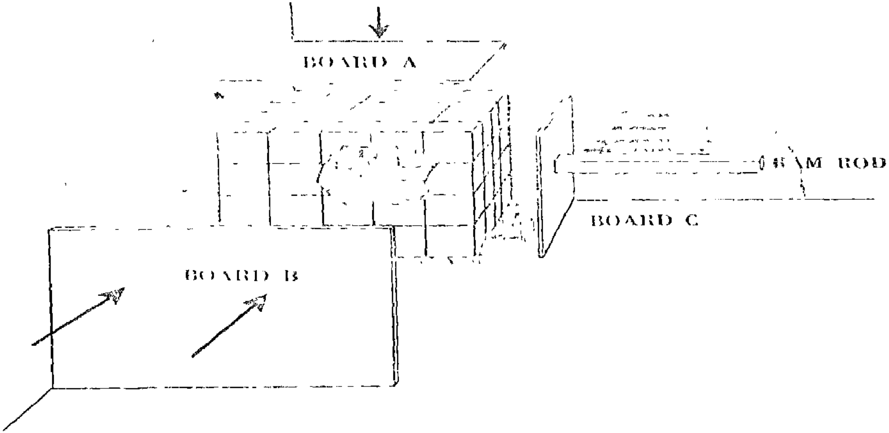

Fig. 3. Conditions for formation of igneous rocks

representing the block formation of the rocks, the force applied through the ramming rod representing accumulating weight of sediments deposited in the ocean which pushes the magma away from the ocean and towards the land masses). Compare the materials and forces as in the model with the situations in the earth, visualized by the geologists. Vary this experiment to try other ideas about the situations.

(b) Demonstrate a volcano model. (*Unesco Sourcebook for Science Teaching*, p. 63).

6. *Metamorphic rocks are formed during mountain-building activities*

Fold different colours of crepe paper, or cloth, or modelling clay to represent the different layers of rock formations in the earth's crust. Lay them on a table. Hold one end firmly against the table and slowly compress the other end that is being held. Let the pupils observe the changes in the set up of layers. Use this activity to initiate discussion on how rocks are metamorphosed. (Extreme heat and pressure cause changes in the structure of rocks and both of these are a part of the process of mountain building)

IV. CONCEPTS TO BE LEARNT IN THE STUDY OF PROBLEMS

1. (i) Rocks contain minerals.
   (ii) The different kinds of minerals in rocks cause them to have different colours.
2. (i) Rocks are composed of one or more minerals.
   (ii) Rocks can be classified according to their formation.
   (iii) Sedimentary rocks are layered in structure.
   (iv) Igneous rocks are columnar in structure.
   (v) Metamorphic rocks are foliose, banded or massive in structure.
3. (i) Minerals can be identified by their characteristic chemical and physical properties.
   (ii) Some of the common minerals can be identified by their lustre, hardness, specific gravity, colour, streak, and characteristic crystal form.
   (iii) Geologists identify minerals by elaborate tests and techniques.
4. (i) Common sedimentary rocks are sandstone, shale and limestone.
   (ii) Sediments are deposited by natural forces like moving water, wind, and gravity.
   (iii) Most sedimentary rocks were formed by the consolidation of different kinds and sizes of sediments deposited by water.
5. (i) Granite, syenite, rhyolite, and trachyte are common igneous rocks.
   (ii) Igneous rocks were formed from molten mixtures of minerals (magma) that solidified on cooling.
   (iii) Igneous rocks have been formed both on the surface and below the surface of the earth.
6. (i) Marble, slate, quartzite, gneiss, and schist are common metamorphic rocks.
   (ii) Metamorphic rocks have been formed out of pre-existing rocks below earth's surface during mountain-building activities which involve great changes due to extreme heat, pressure and chemical changes.

V. CULMINATING ACTIVITIES

1. Encourage pupils to collect rocks and minerals.
   Discuss some of the rules that a good rock and mineral collector follows.
2. Help pupils identify minerals and rocks they collect, performing ordinary tests and consulting tables of data. Any geologist in

the locality may be consulted.

3. Arrange an exhibition of the rocks and minerals collected and identified by the pupils.

VI. NEW QUESTIONS

Let pupils find out answers to the following :

1. What are the different geometric shapes of crystals found in minerals ?
2. Why do some of the rocks have smooth round shapes ?
3. Why do geologists mine rocks and minerals ?
4 Are ash, clay, and mud minerals ?

VII. RELATION WITH OTHER SCHOOL WORK

1. Relate with the teaching of weathering forces in geography.
2. Relate geometric forms with the shape of crystals.
3. Relate field visits to places like river-bed, exposed rocks, road under construction, and hills for collection of rocks and making observations such as structural forms of rocks.

VIII. RESOURCES

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NELSON, W. HYLER, 1960. *Rocks and Minerals*, Wonder Books, New York.
HARBERT S. ZIM, and others, 1957 *Rocks and Minerals*. Simon and Schuster, New York.
LEWIS AND POTTER 1961. *The Teaching of Science in Elementary School*, Prentice Hall, Englewood Cliffs, N. J , Chapter VI

SCIENCE ABROAD

PROGRAMMED INSTRUCTION
DEVELOPMENT OF A NEW FIELD

DONALD A. COOK

Director of Research and Development, Basic Systems Incorporated

An important innovation in the field of learning is attracting increasing attention in educational circles in many countries. The method is known as programmed instruction. Early tests of the new technique open the possibility of a radical improvement in the process by which the individual learner masters a body of subject-matter. Based upon experimental studies of the learning process, notably by the Harvard psychologist B. F. Skinner, the new method may prove especially important at the present moment, when a need for excellence in education is coupled with a need for extending educated skills to an extremely broad base.

The method concentrates upon careful design of the interplay between learner and course materials. The instructional materials are called 'programs' Programmed instruction is sometimes less accurately referred to by the term 'teaching machines' because of the mechanical housing sometimes used to present programs to students. Such machines, however, are usually optional rather than necessary.

Method of Programmed Instruction

A student who learns by the method of programmed instruction will confront the materials of his course in a manner which differs strikingly from his approach to the textbook. The course content is broken down into a very large number of small steps. These are presented to the student one at a time, in the proper order. Each step—called a 'frame'—takes the student through the following instructional cycle: (1) An element of *instruction* is presented through a statement, example, definition, labelled diagram, or other means (2) The frame then calls for a *response* from the student a response utilizing the bit of instruction he has just learned He must answer a question, fill in a blank, complete a picture, transpose the terms of an equation, or otherwise actively construct and record his response. (3) Immediately, the student is given *tutorial appraisal* of his response through presentation of the correct answer, which he is able to compare with his own. (4) He then advances to the next frame, and the instructional cycle repeats itself.

The technique of presentation of programmed materials can be closely approximated by the use of ordinary index cards The work of a course or unit might appear on 10,000 such cards, with each instructional step requiring one card on whose front side the frame (with its instructional material and call for response) would appear, and with the answer to each frame on the reverse. Other types of format control have been designed, appropriate for large-scale production and distribution, and these will be described below.

As an illustration, we present in the Appendix an example of material prepared for instructional programs. This is designed to illustrate the nature of the instructional frame, the types of response which may be called for, the feedback role of the answer or confirmation, the importance of the sequential organization of the material, and (through excerpting) the rate of advance which is possible through effective programming.

Advantages of Programmed Instruction

The method of programmed instruction is designed to bring together in effective combination a number of principles of learning established through laboratory research. The requirement of *active response* ensures that the student interacts with the course material and eliminates the danger of passive exposure The principle of *immediate confirmation* embodied in presenting the right answer after each step serves to reward correct behaviour immediately; motivates the student to progress; makes his progress explicit and measurable and prevents the accumulation of undetected misunderstanding or error. The principle of *small steps* has two major effects. First, the entire instructional cycle—new knowledge, active application, tutorial feedback—can now take place several dozen times, even as much as a hundred times, in one conventional class hour; this contrasts with the widely spaced and less effective intervals of traditional teaching. Second, small steps permit intensive and careful design of the instructional sequence, thus permitting application of the most powerful pedagogical methods.

The effective and simultaneous realization of those desirable features of instruction leads to a number of important gains in the educational enterprise. Chief among them are the following.

1. Through programmed instruction, a great proportion of educational work can be individualized and made more flexible. Each student can advance through the program at his own rate. The rapid learner is not held back by the group, while the slow learner is not shamed by his modest pace. In both cases the student, rewarded for each correct response, is secure in what he knows at every point in the program. Both rapid and slow learners are freed from bondage to the compromises of the classroom ; and forced interruptions, such as illness may cause, no longer mean that important material must be missed. If a student moves, he merely takes his program with him.

2. The achievement of these improved conditions of instruction has brought within view a new and powerful educational ideal : that of *learning without errors*.

The provision for active response leaves a record of mistakes on the part of students which can be traced exactly to the relevant details of the program. This fact gives a basis for the revision of programs so as to eliminate those errors. Research work in the revision of programs through several stages of development has demonstrated the feasibility of this idea. Programs revised by the addition of new frames to 'thin out' difficult material not only generate fewer errors, but may even take less time to complete.

3. Thus the record which stores the effects of an instructional sequence has a dual importance. Not only does the student know where he stands, but so does the designer of the program. This fact now makes it possible for the art of teaching to join forces with the science of learning, thus establishing programmed instruction as a powerful pedagogical technique. The student learning from a program can make contact with the best thinking in the field, and simultaneously can benefit from all achievements in the art of teaching. Both improvements are embodied in the instructional program.

4. There is every sign that programmed instruction will lead to a series of improvements in the logistics of education. Programs permit each teacher to work effectively with many more students than is now feasible. Further, the nature of the student-teacher relation is altered. The teacher need not spend class-time in recitation and drill, but can emphasize individual attention, seminars, discussions, and other creative activities. Independent work on the part of students is encouraged. Through inspection of a student's program, the teacher is apprised of any difficulties that the pupil may be encountering. Not only is class time

employed more strategically, but the teacher is relieved of routine correction of papers outside of class time. These clerical functions are built into the instructional program, where they are not only automatic, but also far more effective.

The prospects just described justify the expectation that this advance in educational method will bring in its wake a major elevation in the role and status of the teacher.

5. The advent of programmed instruction should also lead to changes in curriculum design, as well as in the present grading system and its results. When the functions of textbook, teacher, and test are combined into one process—the instructional program—much more efficient realization of educational goals becomes possible. When all students can be reasonably expected to complete a program, marks and grades merely indicate degrees of progress, and the threat of permanent low grades on one's record is removed. An objective criterion—mastery of the program—is restored, for each learner to attain in his own time. The teacher no longer need bargain with students over marks—a procedure now institutionalized in the practice of 'grading on the curve'.

Changes such as these will aid in the design of curricula with effectively taught contents and uniformly upheld standards.

The Presentation of Programs

A number of methods have been developed for the presentation of instructional programs, all designed to fulfil the basic conditions of small steps, active response, immediate feedback, and individualized rate of progress. As mentioned above, an ordered series of index cards, with answer to questions on the reverse of each card, provides a just approximation A small machine has been found to provide many advantages while remaining compact and flexible. The machine serves to house the program, which is printed on a series of sheets, discs, or rolls placed within. A window in the machine exposes one frame at a time. The student's response is written in the space provided by a second window. When the student moves the program ahead to the next frame the correct answer comes into view ; meanwhile, the answer he has written moves beneath a transparent cover. Thus the student can compare the two answers, but cannot change his own. After this comparison—which confirms a correct answer and also rewards it—the student advances the program on to the next frame.

Some types of machines, such as those used to teach spelling to young children, will not allow the program to be moved forward unless a correct answer is given. Other types of machines will make an automatic tally of right and wrong answers. Still others present special remedial program segments designed to eliminate the basis for particular incorrect responses. Many machines can be used with an attachment allowing answers to be written on a separate scroll or sheets, thus permitting re-use of the same program.

Such machines vary a great deal in size, complexity, flexibility, and price. Looming still larger is the prospect of programs in book format, ignoring the machine entirely. If excellence is the keynote, however, repeated and precise testing, by both the programmer and the potential user, will become a dominant factor.

From this entire ferment, then, educators and psychologists in the United States have drawn the hopeful vision of a reformed educational process, achieving through programming a new degree of effectiveness and interest. And for the first time, education of this quality will become available to broad sections of the population.

APPENDIX

ELEMENTS OF ATOMIC STRUCTURE

(Designed for students in the 10-11 age group)

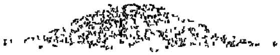
This article contains a short example of an instructional program. It illustrates the method of teaching known as 'programmed instruction'. Programmed instruction is a high-speed teaching technique developed by psychologists and educators over the last twenty-five years. This technique has recently enjoyed some important successes in the classroom as well as in industry. The three most important features of programmed instruction are :

1. Active student participation
2. Small steps and low error rates.
3. Immediate confirmation of every response

If you go through the sample program, you will learn the elements of atomic theory in about seven minutes. You will find that the program builds upon what you already know, and advances by degrees towards increasing levels of complexity

Some of the questions in the program will require you to write in one or more words. Other questions will require you to draw diagrams. For the program to be successful, it is important that you actually write the answers into the program ; 'thinking' the answers is not enough. It is also important that you do not look at the given answer until you have completed your own. You must shield from your view any material which might give you undesired prompts.

1. This is a pile of pebbles.



The pebbles are easy to see because they are large. If you make them smaller, you have sand. If you make them still ______ you have powder.

ANSWER TO QUESTION 1

smaller

2. If you keep making powder particles smaller, you eventually end up with atoms. Why can't you see atoms?

All matter is made up of atoms. Does this mean that you are made up of atoms?

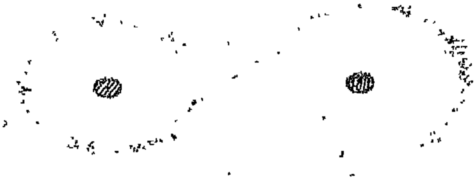
(yes/no)

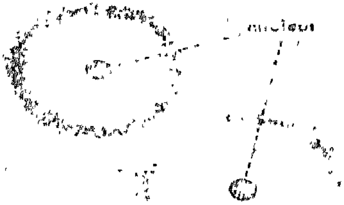
ANSWER TO QUESTION 2

They are too small.

yes

3. The center of the atom is called the nucleus. Label the nucleus of each atom.

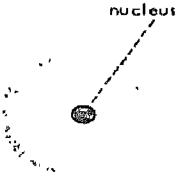




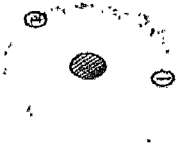
4. The center of the atom is called the n____________________ (Spelling hint: the _e_ goes in front of the second _u_.)

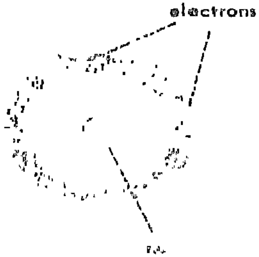
nucleus

5. Draw in the nucleus of this atom and label it.



6. Tiny particles called electrons travel around the nucleus. Label the electrons and the nucleus of this atom.





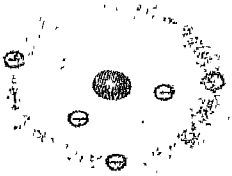
7. The electrons travel around the ____________

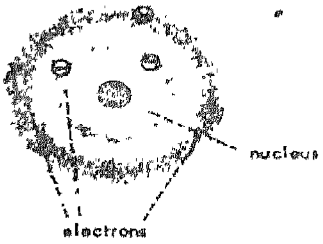
nucleus

8. The particles which travel around the nucleus are called ele____________.

electrons

9. Label the parts of this atom.

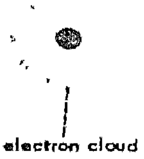




10. Where do electrons travel?

around the nucleus

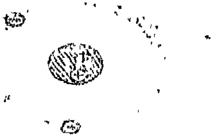
11. We cannot locate the exact position of the electrons. Therefore, we think of them as an electron cloud. Label the electron cloud in this diagram.

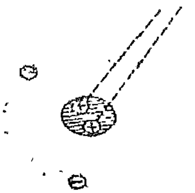


12. Since we cannot locate electrons, we think of them as forming an ____________ __________.

electron cloud

13. The nucleus of an atom contains one or more particles called protons. Label the protons in this atom.





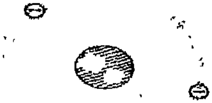
14. Protons are found in the ________________.

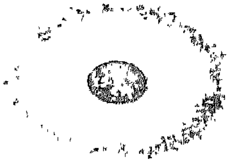
Where are the electrons found?

nucleus

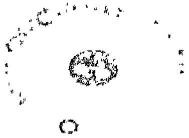
around the nucleus

15. Because a proton has a positive charge, we use the symbol ⊕ to stand for a proton. Draw two protons in the nucleus below, using this symbol.

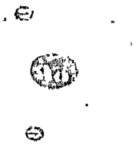




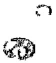
16. We use the symbol ⊕ to stand for a proton because a proton has a ______ charge. An electron, on the other hand, has a negative charge. Can you guess which symbol we use for an electron? Draw in the missing symbols.



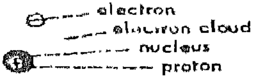
positive



17. Label four parts of this diagram:



Protons are positively charged particles.
Electrons are ______ charged particles.



negatively

18. Write one sentence which contains the following words: proton, nucleus, atom.

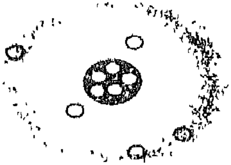
Now write a sentence which contains the words proton, positive, charge.

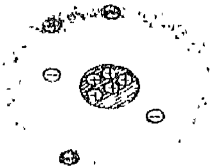
The proton is found in the nucleus of the atom.

The proton has a positive charge.

(or any equivalent sentences)

19. Fill in the missing symbols.





20. Write one sentence using the words: electron, *negative*, *charge*, *and nucleus*.

An electron is a negatively-charged particle which spins around the nucleus of the atom.

(or any equivalent sentence)

21. What letters of the words neutral and neutron are the same?

Neutrons, like protons, are particles found in the ______________ of the atom.

[illegible]

[illegible]

proton

electron

neutron

☑ proton (·)

☐ electron (+)

☑ neutron (−)

22. The ______ has a positive charge.

The ______ has a negative charge.

The ______ doesn't have any charge;
[illegible]

23. Match [illegible] with their symbols.

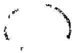
[ ] proton (·)

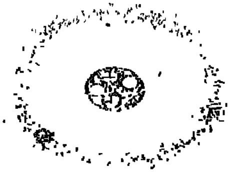
[ ] electron (+)

[ ] neutron

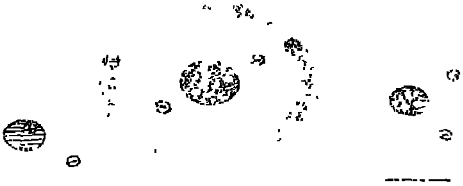
Place check marks next to the particles that are found in the nucleus.

24 Complete this diagram of an atom by drawing in two electrons, two protons, and two neutrons. Be sure to circle the symbols.





25. The number of protons in an atom is called its atomic number. Underneath each atom, write its atomic number.

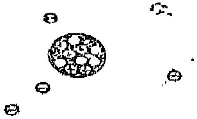


______ ______ ______

---

1 ______ 4 ______ 2 ______

26. Why is the atomic number of this atom five?



If it had six protons, its ______ ______ would be six.

---

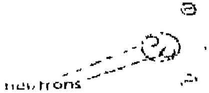
because it has five protons

atomic number

27. The atomic ______ is the ______ of protons in the nucleus.

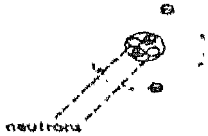
THE SAME WORD GOES IN BOTH SPACES

This atom has an atomic ______ of two. Draw in the missing protons.



number number

number



28. An atom has eight protons. Its ____________ ______________ is eight.

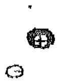
---

atomic number

29. What is the atomic number of an atom?

Draw a diagram of an atom which has one electron in its electron cloud and an atomic number of one. Leave out the neutron.

The number of protons in its nucleus.



IF YOU HAVE ANSWERED THIS LAST QUESTION CORRECTLY, YOU HAVE MASTERED THE ELEMENTS OF ATOMIC THEORY.

EXPERIMENTAL WORK IN GENERAL SCIENCE

T L. GREEN

Unesco Expert in Science Teaching, Ceylon

Widespread attempts are now being made in Asian and other tropical countries to introduce the teaching of science as part of an overall advance in education. In general, these attempts are being made in the face of many difficulties, among which shortages of staff, school building, laboratories, equipment, and the background factor, lack of finance—are all apparent. While it is natural that attention should be concentrated on this latter element, other factors should not be overlooked Among these is the attitude of many teachers to the question of experimental work in the early stages of science teaching.

Attitudes are born of the experience of the individual. That experience is moulded by the social pressures and value systems which come from the cultural heritage of the society in which he lives. While Asian countries differ widely from each other (in some ways almost as much as east from west), there is one feature common to many of them. This is the strength of the verbal tradition. However ancient the art of writing may be, it must be remembered that the ability to read has, until very recent times, been restricted to a social and cultural elite. A few could read—the mass had to remember, and it was by the oral technique of verbalization that tradition was passed from generation to generation ; it was by his verbalization that the 'learning' of the individual was estimated. 'Do you know ?' not 'Do you understand ?'. To know by heart was often the criterion of entry into the professions, the public service or the priesthood. This tradition is by no means dead. It is carried on in those social institutions which have been least affected by westernization, and it is actively fostered by examination systems and school procedures which place a premium on remembering rather than on understanding—on acceptance rather than on criticism.

A second feature, common to many Asian societies, is the low status of the manual worker. The artist in words was a poet ; the artist in materials was a mere potter, carpenter or metal worker. Prestige went to the one who talked or wrote, not to the one who made or did. With differences in prestige went economic differentiation, and both were most marked where caste backed up what culture had decreed.

Against these backgrounds, science education in the past was restricted in extent and used as a qualifying means for entry to the professions.

Now that it is becoming more widely available, it is clear that these background factors are still operative and lead to a tendency to teach science as though it were only a theory. There are three major reasons for seeking to alter this situation and to emphasize the experimental aspect :

1. All scientific knowledge basically depends upon phenomena which have been observed, recorded and analysed under controlled experimental conditions. Experimentation has played a major part in the historical development of scientific knowledge.

2. Many scientific phenomena are so difficult to observe (because of their scale of magnitude, their velocity, their structural complexity, etc.), or so difficult to understand (because of the complexity of the ideas involved) that experimental control and analysis is an essential element in observation and understanding

3. Science teaching should aim beyond the informational gains, which we test by examination and with which we are too often content. It should also be our aim to develop scientific attitudes, interest in science and the qualities of resourcefulness and inventiveness. To neglect the practical component and the experimental side in science teaching is to reduce the chance of realizing its most important possibilities.

Practical work, however simple in scale, is thus an essential element of a scientific education Yet, despite this, for reasons referred to earlier, it is just this side of school science which is most neglected or approached in the wrong way. Where it is neglected, it is not uncommon to find teachers claiming that practical work is 'unnecessary', since they can get their pupils through examinations without wasting time on experiments. Where 'practical work' is attempted, it may be wrongly approached, either in terms of content or method. In the former case there is often a confusion between doing practical work and 'knowing about doing it'—so that one meets cases where pupils have filled record books with drawings of apparatus which they have never seen, but have copied from book or blackboard. In the second case, that of method, the approach has been that of uncritical acceptance of a dictated procedure in order to confirm a value, quantity or relationship which has already been disclosed.

These procedures are defended by those who practise them in various ways : first, perhaps, by reference to the general difficulties of supply, amenity and finance mentioned in the opening paragraph ; secondly, of course, by pointing out that in the early stages of the teaching of general science there is little practical work which is 'possible', and that at a later stage, in the first public examinations (the School Certificate, General Certificate of Education, etc.), there is no practical examination—and even at a still later stage there may be no practical paper, even if practical record books have to be submitted.

Those who offer such defences have failed to understand the position of science in education and have abrogated their responsibilities in two ways to the individual child, who should have been helped to develop skills, attitudes and personality qualities as well as to gain scientific knowledge ; and to society, in whose service such skills, attitudes and knowledge should be used. Moreover, those who seek a defence in 'shortage' and 'difficulties' have failed to see these as an active challenge, because they have failed to appreciate the need for interest, initiative and resourcefulness in themselves as science teachers.

In order to rectify this situation it is necessary for teachers of science, for those who are training to be science teachers and for those responsible for such training to accept four basic propositions :

1. Scientific method is not only a way of doing things, but a way of thinking about things and a way of thinking about how to do them ;
2. Scientific modes of thinking can be applied and demonstrated in very simple situations ;
3. Experimental work, characterized by sensitivity of method, precision of result, elegance of design, can be conducted with simple apparatus ,
4. Practical work is not the basis of understanding only, but also of those experiences which are most likely to lead to resourcefulness and inventiveness.

But acceptance of such propositions is not enough. They must be acted on. And it is at this point that difficulties confront the writer of so short an article, as the present one. In view of the limitations of space, the first and fourth propositions will be left as postulates, while further brief reference will be made to the other two. Of these it will be noted that one (proposition 2) refers to *thinking*, while the other (proposition 3) refers to *doing*. It is the former which is the more difficult to deal with especially for those whose scientific education has been a training in practical procedure rather than in theoretical criticism.

In attempting to argue the case for the second proposition it must be pointed out that it is largely a matter of the teacher convincing himself of its truth. This he should do by careful examination of suitable examples of the kind met with in even the early stages of science teaching, cases in which, all too often, pupils are told the solution to a problem or the facts relating to a situation and seldom helped or encouraged to think it out for themselves. This may be seen in considering the shape of the earth, in simple terms, without reference to the complications of modern geomorphology. Too often the possibility of observation and experiment is ignored here.

The potential evidence, excluding that of a very complex nature, is :

(a) Successive appearance of mast, funnel and hull of a ship as it approaches an observer on land.
(b) The curvature of the horizon.
(c) The shape of the earth's shadow at a lunar eclipse
(d) The possibility (at least in theory) of circumnavigation.
(e) Evidence of high-altitude photography.
(f) Angular position of the Pole Star observed from different latitudes.

It should be noted of these that :

1. (a) and (b) can only be observed by those who live near or pay a visit to the coast.

2. (c) is only to be seen by those who are at the right place when such an eclipse takes place.

3. (d) circumnavigation is also possible around a disc-shaped earth.

4. (e) such photographic evidence is likely to be available only to those who have access to a large amount of background reading materials, such as 'western' popular science magazines

5. (f) few school children are likely to have experienced such changes of latitude, few schools will have a means of measuring the altitude and even fewer will possess nautical or other tables of astronomical data.

Most commonly-used teachers' and elementary science books refer only to (a), (b), (c) and (d) as evidence ; (e) is so recent as not to have got into school books while (f) is considered too complex. Such a situation cannot properly be accepted by a teacher who wishes to teach an understanding of science and its methods, as distinct from a remembering of data or statements. He would wish to go further into the matter—and our next problem is to consider what else he can do.

So far as (a) and (b) are concerned, direct observation can be made if location or opportunity permits it. If not, recourse must be made to the usual diagram with a greatly exaggerated curvature to the earth. More can be done. Instead of being content with a moving ship and a fixed observer, discussion can be devoted to the reverse situation and also to the effect of the relative altitude of observers at different heights above sea level. 'Answer' can be worked out in discussion and in diagrams—and the pupils be allowed to try their hand first. Actual observation is, of course, the most desirable approach, if this is possible and in this case a metre rule should be observed against the horizon whose curvature can then be more readily appreciated. It must not be supposed that a single observation or a single reference to a diagram will result in complete understanding. The data of observation and the facts presented in a diagram must be discussed, talked about and used, so that the meaning becomes part of a mental experience. Moreover, it may be possibe to profit from other opportunities to make observations, for the effect of the earth's curvature is sometimes discernible on land—for example where a tall tower is observed across a wide plain.

Not every one is fortunate enough to witness a lunar eclipse, but it can be simulated with models and 'explained' with diagrams. This, however, is not enough, because the observed phenomenon remains only an 'explanation' if it is not first realized that only a sphere will throw a circular shadow (though only part of an arc is seen), in spite of variations in the position of the illuminant. This point should first be talked about, to stimulate thinking. Take a circular disc and hold it vertical with a flash lamp on a line normal to the centre of the disc. What shape will the shadow be? Then start tilting the disc—what will the shadow be? Finally, with disc edge on to light—what will the shadow be? Then after discussing, predicting and making sketches, the matter can be put to the test.

Thus one demonstrates that to explain the curved arc of the earth's shadow it is not enough to say that the earth is 'round'—for a disc is round.

Similarly one may explore the shadow cast by a cone and a cylinder—finally reaching the conclusion that only a globe casts a shadow with a curved edge whatever the position of the light.

In the case of (d) it should be easy to show that, in relation to a fixed central point (i.e. constant distance and keeping the point abeam) a ship could travel around in a circle and come back to its starting point. This, however, is not a proof that the earth is a globe—because, as we have said, those conditions can be fulfilled on a disc. The essential point is that continual movement in a constant direction will, on a globe, always result in return to the starting point. The postulate that the earth is a disc, might well be examined in the same way—when it will be seen to be untenable. A ship following a course directly away from a fixed central point (i.e. along a radius) would come to the 'edge' of the world. So far this has not been achieved by even the most intrepid explorer.

Even at this point, however, the hypothesis of a disc-shaped earth cannot be dismissed. Instead, one should ask the question, 'If the earth were a disc what else, other than travel around it, or across it, could be affected? No pupil of elementary science will be able to provide an answer, and yet, helped by his teacher he can make and apply a relevant observation. This concerns the behaviour of the plumb-line, the suspended weight used in building construction which always hangs vertically.

If students really understand the principle of this attraction between the centres of gravity of two very unequal masses they should be able to make a simple diagram, showing the positions which would be assumed by plumb-lines at different points around its surface. In each case if the line is extended through the weight it will pass through the C/G of the earth. Reading, looking at pictures, examining tool catalogues and even asking about the exports of tools will show that the plumb-line is world wide Always it is the test of the vertical

Now, assume that the earth is a disc, like a thick circular cake, draw its section, mark the C G, and ask the class to show how plumb-lines would behave. If the pupils are indeed able to use their understanding they will at once know that the picture they must draw, in virtue of their knowledge, does not agree with their direct and indirect experience. The disc hypothesis would appear to be untenable, but not without submitting it to another test

Many children live in culture patterns in which some kind of knowledge of the heavens exists. The fisherman uses the stars as an aid to navigation. The farmer often times the season against the appearance over the horizon of a particular constellation The traveller on land guides himself by a star. The astrologer uses knowledge of the annual change in the skies, seen in the zodiac. Also he knows of the use and existence of the 'Ephemeris'. Thus three things are commonly accepted, or are not difficult of acceptance . that the stars are at 'infinite' distances, that there is (for the northern hemisphere) a Pole Star, and that some kinds of knowledge about the stars can be tabulated in quantitative terms. Further, by searching the literature of adventure and travel it should not be difficult to come on some useful phrases, 'High above the snowy wastes the Pole Star glittered', 'On the horizon the Pole Star dipped steadily down, night by night, as the ship ploughed her way south'. The inference is obvious. The angular position of the Pole Star varies with the latitude of the observer, a fact which can only be explained by assuming that the surface of the earth is curved, and not flat. A diagram, as large as possible, should be made to demonstrate this, together with one to illustrate the inference that an infinitely distant Pole Star would subtend a constant angle of 90° to an observer crossing a flat earth with a diameter of the same order as that of our earth.

Moreover, if the Pole Star were not so distant, its angular position of 90° with the observer immediately below it would change as he travelled away from the original position Each successive moment of, say 2,000 miles would cause a successively smaller angular change, but the Pole Star would always be visible. On our spherical earth, for each successive moment of the observer of 2,000 miles the angular position of the Pole Star changes by 30°. Finally it becomes invisible.

This may not be a complete demonstration of the scientific method, but it is a great improvement on the common approach which consists of making a statement, less often of offering evidence in its support and very seldom of subjecting it to critical attention. In what has been offered such criticism has been channelled along two lines :

First, by asking : Is there alternative explanation ?

Secondly, by saying : If this is accepted—what must follow?

Precisely the same approach can be made to other topics in the early stages of general science teaching. Thus, having explored the shape of the earth, and having accepted a particular hypothesis, it is customary to turn to the movements of the earth, its rotation and its orbital motion.

So far as rotation is concerned the usual evidence is . (a) the succession of day and night ; (b) the apparent movement of the sun ; (c) the changing position and length of shadow round a pole ; and (d) the apparent shift in position of fixed stars.

It is usually found that these four kinds of evidence are supposed to be observed, (a) and (b) being a matter of common experience, (d) being observable by any one who takes a little trouble and (c) to be treated practically. In fact (c) is often neglected and experiment is replaced by examination of a textbook diagram. As this probably relates to conditions some 30°—60° north of the equator it gives a false picture of conditions obtaining around the equatorial zone It is not uncommon to find even training college lecturers who have never performed this simple experiment. They have relied upon book pictures which do not apply to their local conditions.

Foucault's Pendulum, by its demonstration of procession or wooble, may be cited as evidence that the earth spins like a top. The original experiment was performed in Paris and demonstrations may be seen every day in the London Science Museum. In how many other places is this possible ? Even those who suggest that it should be performed, and even give diagrams, seldom give any of the requisite data (the need for a heavy weight, a long wired and a turn buckle or rotating suspension). And again the effect of latitude is ignored.

The gyroscope offers the only instrument with which we can conveniently demonstrate experimentally the rotation of the earth, because its axis preserves its orientation in space, irrespective of the alteration of position of its frame and the earth, due to angular movement. But gyroscopes are not available as pieces of school apparatus.

Time zones and the need to alter clocks when travelling on an east-west axis, as well as the apparent differences in flight times on outward and inward flights, are related to the rotation of the earth. Time zones are dealt with in geography books but the good teacher, who appreciates the difference between remembering and understanding, as aspects of knowing, will seek to supplement the situation by getting schedules, route data and time tables from shipping and air companies.

The suggestions which have been made in relation to the second proposition cited early in this article, may perhaps be taken as relevant also to the fourth For, in seeking understanding through experimentation, experience is an unavoidable outcome, and one likely to lead to resourcefulness and inventiveness. It may be objected that the topics selected, like an elementary study of astronomy, offer little chance for experimentation. That is why they offer such good opportunities for critical thinking and discussion and call for so much in the way of resourcefulness and inventiveness. Those who need help in regard to simple experiments, observations and demonstrations in this field of science should turn to chapter VI of the *Unesco Sourcebook for Science Teaching.*

As a conclusion to this article it may be fitting to point out that while the title used the word *experimental*, the article itself has largely been concerned with the *theoretical.* And that is exactly what is most needed in the teaching of science -that practical work, instead of being a passive acceptance of demonstration or an automatic repetition of procedure, should instead be a constantly critical commentary on what is being done. In brief, theory must be both the stimulus to practical work and the final bar against which its findings are arraigned.

SCIENCE LABORATORY EQUIPMENT FOR SECONDARY SCHOOLS—AN ANALYSIS[*]

JINAPALA ALLES

Assistant Director of Education, Technical and Scientific, Ceylon

General Science is now accepted as an essential component of the curriculum for the 11-14 age group. General Science, Physics, Chemistry and Biology are important subjects in the curriculum for the 14-year old group.

The organization of science teaching in secondary schools involves a number of problems. The main problems relate to the teacher, his initial training and the maintenance of his competence at a high level. Another important problem, however, is the establishment and maintenance of a number of teaching laboratories and simple science teaching units.

The effective teaching of science requires a minimum of relatively highly specialized apparatus and materials. Thus three questions have to be considered :

1. What *type* of equipment should be issued ?
2. *How much* of each item should be issued ?
3. What is the *minimum* quota of apparatus and materials necessary for efficient teaching at the various levels ?

These questions are significant from the point of view of the administrator and the organizer responsible for the establishment, administration and maintenance of a school science teaching service.

These questions become even more significant when the country concerned is compelled to import almost all items of equipment and materials from supply centres several thousand miles away. A casual approach will entail expense, inconvenience and inefficiency. When the teaching of science was limited to a few selected schools the problem was not particularly acute, but with the rapid extension of science teaching as a core subject in the curriculum, these questions become of critical importance.

When the number of laboratories concerned is small, efficiency may be assured by providing something more than the minimum ; but when the number is large this solution is extravagant and, therefore, not permissible. For example, if only two schools are involved and each requires

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[*] A paper read at the Annual Session of the Ceylon Association for the Advancement of Science, 1958. A preliminary note of the ideas developed here was presented at the All India Science Teachers' Association [of *Vigyan Shikshak* (The Science Teacher)] Delhi, No. 1958.

[illegible], it might [illegible] the provision of two to each school, whether deliberately or through an error of judgement, involves only an excess expenditure of about Rs. 700. But if 400 schools are concerned a similar error will mean an excess expenditure of about Rs. 160,000. A few such errors can account for an entire year's funds. In the case of less costly items, the number of items is much larger and the corresponding waste may be comparable. In view of this, it is clear that standard lists of apparatus are a necessity and minimum amounts consistent with efficiency, have to be recognized.

Standard lists of equipment for secondary schools are relatively easy to prepare, if highly experienced veteran science teachers are available. They can normally prepare their own lists which are, more or less, satisfactory; but from the administrator's point of view, such *ad hoc* lists have little value. The administrator desires lists which satisfy three criteria:

1. They should give specific guidance as to the manner in which the recommendations of the standard lists may be modified when there are variations in the numbers of laboratories, the capacity of the laboratories and the number of pupils.

2. They should give a detailed explicit indication of the basis of the list so that changes may later be made to the recommendations themselves with an understanding of the significance of such changes.

3. They should be capable of being acted on efficiently by an average worker with a reasonable knowledge of the subject.

Standard lists when prepared subjectively without an explicit analysis of the problem do not normally meet these requirements.

Many lists have been prepared and released for general use by various organizations. The Unesco series of 'Inventories of Apparatus and Materials for Teaching Science' is one of the most ambitious of such attempts. The All India Council for Secondary Education has published lists for higher secondary schools in India. The Science Masters' Association of Great Britain and the corresponding teachers organizations in America and elsewhere have released analogous lists from time to time. They provide valuable guidance, in general, as to the types of equipment which is desired in teaching laboratories. Even when this requirement is adequately met, the answer to the question, 'How much of each item ?' is not always indicated in a useful way. When the numbers are given, the basis of deduction is not sufficiently clear and *explicit* to permit of systematic variation to suit changingconditions from one location to another. Further, when minor variations in laboratory teaching practice are adopted the repercussions of such decisions on the equipment and materials position is not always clearly evident and no direct guidance on the extent of reserve stocks to be held in a central store is available in any of the better known lists.

When the Department of Education in Ceylon launched the present programme of extension of science teaching all these questions arose; and the problem did not find direct, satisfactory solutions in the available lists.

The limited number of trained personnel available and the limitations of funds demanded a careful, rigorous analysis of the problem.

The approach and framework of thinking outlined in this paper is the outcome of an attempt to solve the problem. A few examples will be given to illustrate the ideas which are being presented. The complete lists with detailed analysis of the make-up will be released later.

The selection of apparatus and materials is governed by the following principal factors :

(i) The subject or subjects taught in the laboratory.
(ii) The level at which it is taught.
(iii) The manner in which it is taught.

This will involve :

  (a) The purpose for which it is taught.
  (b) The interpretation of the syllabus.
  (c) The relative emphasis placed on demonstration work, group work, and individual work.

(iv) The environment in which the subject is taught.
This will involve considerations, such as, rural or urban ; availability of sources of supply ; facilities for teachers to mend and repair equipment ; the extent of assistance available.
(v) The capacity of the laboratory.
(vi) The total number of pupils involved.
(vii) The total number of hours involved.
(viii) The teacher, his background and training.
(ix) The pupil, his background and training.
(x) Other factors.

Some factors (which are implicit in others) are referred to explicitly because of their importance.

In the analysis, each subject and each level of work, etc., will require a particular approach, but the general consideration will remain essentially the same.

In order to make lists functionally valuable, it is desirable that the above factors be incorporated, systematically into the framework of thinking with the adoption of appropriate assumptions, guiding principles, and rules.

To facilitate work and complexity, it is desirable to recognize two or more distinct levels of work in the school.*

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* for Ceylon schools, the following sub-division is recommended .
(i) 6th, 7th and 8th standard level (11 to 14 years).
(ii) G.C.E. (ordinary level) (14 to 16 years).
(iii) H.S.C. level (16+).

It is desirable to recognize the main subjects separately and provide lists for each. In general for secondary school work the following four subjects are relevant :

(a) General Science
(b) Physics
(c) Chemistry.
(d) Biology.

A very important assumption must relate to the relative emphasis on demonstration work by the teacher and individual work by the pupils. In general it will be accepted that in the 11 to 14 age group, the work will be mainly *Pupil Aided* demonstration by the teacher. Individual work will be done by the pupils in simple situations, but wherever specialized equipment is involved the earlier statement will hold. In the 16 + age group the work will be largely individual work or group work by pupils. In the G. C. E. (ordinary level) (i. e. 14 + to 16 +) an intermediate situation will be generally accepted.

In underdeveloped countries, initiating programmes of science education, specific recognition of the distance from sources of supply and the non-availability of equipment repair units in close proximity to the school will be necessary. Further the teacher's competence to repair such equipment, competence in glass blowing, etc., will also have specific repercussions on the quantity of equipment issued and that held in reserve in a central store.

The basic framework of thinking which is now proposed follows directly from the concept of experimental science itself It is difficult to define science, but one workable definition is, 'Experimental science is an accumulative, progressive and systematized body of *knowledge arrived at by observation* and experiment –experiment being observation of phenomena under *controlled* conditions' It follows from this that the *primary needs* for the practice of science are :

(i) Aids to observation.
(ii) Aids for control.

The observed phenomena are usually directly or indirectly associated with material substances Hence a third requisite is :

(iii) Materials.

That which is being observed, and experimented on will usually require to be supported or contained. Hence a variety of stands, holders, clamps and containers are essential for the practice of science. A fourth group, therefore, is recognizable, viz.,

(iv) Auxiliary aids.

As the reference is to a *Science Teaching Unit,* a further group of equipment is essential, viz.,

(v) Teaching aids.

All these items of equipment and material will require to be assembled, maintained, etc. Hence a sixth group will be necessary, viz.,

(vi) Tools

In the final analysis, a Science Teaching Unit will, therefore, contain items of equipment and materials capable of being broadly classified into *six* large groups

Group I—Observational Aids

This will include instruments and other apparatus designed for qualitative or quantitative observations relating to mass, length and time, or simple functions of these and the electrical units. If desired this group may be further sub-divided on the basis of dimensions of mass, length and time, etc. In the selection of equipment in this group the degree of precision appropriate to each level can be governed by the simple rule that in each level there should be provision for acquainting the student with a limit of precision, which may be approximately one order of magnitude removed from that which is familiar to the average student.

Group II—Control Aids

In this group will be all items of equipment necessary for controlling conditions associated with phenomena. Some of them will relate to temperature, pressure, volume and, if necessary, these may be sub-divided on the basis of these fundamental conditions.

Group III—Materials

This will include all chemicals, reagents, specimens and other consumable materials essential in a laboratory.

Group IV—Auxiliary Aids

This group will include all such items as are essential for supporting and containing, for example, stands, clamps, bottles, jars, beakers, slides, etc. They may be further sub-divided according to their functional characteristics.

Group V—Teaching Aids

This will include charts, models, prepared slides, museum specimens and other such aids to teaching.

Group VI Tools

The scheme is comprehensive but it is not unambiguous. A critical examination will show that some items of equipment are not easily assigned uniquely, to a particular group. A bell-jar, for instance, may be viewed as a device for controlling the volume or as a device for containing a gas. In respect of a number of other familiar items, similar situations will arise, but this is not a serious weakness and, in fact, is not a new problem. It is a situation with which one is always confronted, when refined classification is attempted. It stems from the fact that things around us are often multi-functional and are not easily pigeonholed This approach provides a satisfactory analytical framework for answering the question, 'What type of equipment should be issued ?'

The question, '*How much* of each item should be issued ?' is less easy to resolve, but it is possible to make an analysis which is resonably satisfactory from a practical point of view.

The number, or quantity, of an item is dependent on many factors and for the purpose of this analysis the Laboratory Capacity (C) and the Pupils Stream Strength (S) are used preferentially as the basis for the treatment.

The quantity or number of any particular item may be considered as the *sum* of the allowances provided under each of the following *four* sections :

SECTION A—An allowance which is independent of (C) and (S). This will be a quota which is primarily for use by the teacher only, or for demonstration work only, or for common use by all.

SECTION B—An allowance which is dependent on (C) but not a simple function of it. This will be a quota provided to cover group work, the number in the group being flexible.

SECTION C—An allowance which is a simple function of (C). This will be a quota provided for individual work or group work of a more rigid type.

SECTION D—An allowance which is dependent on (S) and a simple function of it. This will be a quota provided against damage and for amounts consumed by students in one year.

The above analysis is best illustrated by a number of examples. A few are given below :

Ex. 1. Thermometer 10 to 100°C (for general science age group 11 to 14). This will be an observational aid and the quantity can be deduced as given below :

Allowance under Section A—1

(for use by the teacher and in demonstration work).

Allowance under Section B—3

(for use by groups of students. It is assumed that if the number in the class increases then the number of students in a group will increase, probably from two to three, and it is also assumed that several different experiments, normally not exceeding four, are simultaneously arranged in the laboratory for students).

Allowance under Section C—0

Allowance under Section D—0 (or 1)

(It is assumed that with the age group 11 to 14 the breakage is a negligible figure in respect of an item such as this. It should be noted that the chances of breakage are a function of (S), as thermometers are liable to damage every time they are taken up for use).

Ex. 2. Pressure Stove—(for general science in the age group 11 to 14). This will be a control aid and the number may be considered as being made up below :

Allowance under Section A—1

(for use in demonstration work only).

Allowance under Section B—0

Allowance under Section C—0

Allowance under Section D—0

Ex. 3. Beakers*—Borosilicates glass—400 ml with spout-short-form

(16+ age group ; C=18 and S=30 to 40). This will be an auxiliary aid. The amount will probably be made up as follows :

Allowance under Section A—2

(for demonstration work and for use by the teacher).

Allowance under Section B—0

Allowance under Section C—18

(This will be an allowance for individual or group work).

Allowance under Section D—4

(This is an estimate of the likely damage under these conditions in one year by 30-40 students. In the present context this estimate is only approximate).

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* Many items in a biology laboratory, e.g., Petri dishes, slides, etc., will be analogously treated.

Ex. 4. Glass tubing Soda glass 4 to 6 mm. medium wall
(for the age group 14 to 16 ; C = 18 and S = 30 to 40).
Allowance under Section A [illegible] lb.
Allowance under Section B [illegible] lb.
Allowance under Section C [illegible] lb
(for individual work)
Allowance under Section D [illegible] lb.
(This will be a quota provided for waste and damage in one year).

On this basis it will be clear that a school with a chemistry laboratory for H.S.C. work, C = 18 and S = 30 to 40, will get an initial issue of 24 beakers. A centralized store will keep a sufficient quantity in stock to issue approximately four beakers for each Teaching Unit against damage.

On the other hand a chemistry laboratory for H.S.C. level work, with C = 36 and S = 30 to 40, i.e., a laboratory which is larger but where the stream strength in the school remains the same, will have received 42 beakers made up as follows :

A = 2
B = 0
C = 36
D = 4.

Further an H.S.C. chemistry laboratory, with C = 18 and S = 120 to 160, will have received 36 beakers, the number being made up as follows:

A = 2
B = 0
C = 18
D = 16.

It will be seen that this analysis permits the calculation of the amounts to be issued to various locations on a certain basis of rationality. It is not suggested that in this type of work mathematical precision is possible or even that it is desirable. What is proposed is that a reasonable technique for estimating should be available and one that does not always demand the attention of a highly experienced and trained science specialist. Guess-work is minimized and even when used is recognized as such and not mistaken for careful estimation.

The above reasoning gives preliminary lists from which minimum standards consistent with workability and efficiency may be deduced.

An analysis, such as the one suggested, indicates to what extent the amounts are liable to error because of subjective judgement. Further in the case of a large organization with a network of laboratories it gives specific guidance on the relative amounts of stores that should be maintained as replacements. It also provides a definite indication of the manner in which statistics should be maintained in a centralized store. In theory, and in practice, it should be possible over a period of 5 to 10 years to eliminate the subjective element to a very large extent.

In the analysis, it has been assumed that each subject has a laboratory for itself. The framework of thinking enables one to compound lists for two subjects when these two subjects are taught in the same laboratory The method of doing so will be evident from the analysis

In addition to the administrative need, the author would postulate that the new framework of thinking serves a distinct and vital educational need as well. The teaching of general science will be a real success only if the science teacher willingly and actively exploits the environment to meet the needs of the classroom. In countries, with limited financial resources, an extension of general science teaching is possible only if the teacher is prepared to undertake this. He should do so not only in respect of materials but also in respect of equipment. With a view to meeting this need many have suggested various *improvised* items of equipment. A very significant contribution in this field is the *Unesco Sourcebook of Science Teaching*. But it is important that the substitution of the component readily available in the environment should be carried out with an appreciation of its functional adequacy. It should not be done with a feeling of dissatisfaction because the formal apparatus is unavailable If the substitution is functionally adequate for the purpose, no apology is needed and none should be offered for using it It is important that the teacher and pupils should look upon equipment and materials not in isolation but as connected with specific functional characteristics.

The teacher should not use a tin with a sense of dissatisfaction, all the while under the impression that the thing to have is a beaker. If what he wants is a wide-mouthed container (not necessarily transparent) resistant to sudden changes of temperature but not acid resistant then he should accept the tin with satisfaction because it is functionally adequate.

If he wants a container which is not rapidly affected by acid and alkali and optically clear (but not necessarily resistant to thermal shocks) then any wide-mouthed bottle should be accepted and used without an apology being tendered.

On the other hand if he wants a vessel which is not affected by acid and alkali and resistant to thermal shocks (but not necessarily clear) then a porcelain cup would be functionally adequate.

But if he really wants for his purpose a wide-mouthed vessel which is acid-alkali resistant, optically clear, and resistant to thermal shocks, he is entitled to complain if a borosilicate glass or similar beaker is unavailable

And if, in addition to the foregoing he requires a vessel with a high transparency to infra-red and ultra-violet, then he should demand a high quality clear quartz beaker, as no other will be functionally adequate.

Similarly, Petri dishes, and culture flasks of various types have well defined functional characteristics.

It may fairly be asserted that no teacher should present an experiment to a class without appreciating the functional characteristics of every component

Apart from this, the worker will see possible improvements to equipment when he views them from a functional standpoint.

This aspect of the study of equipment is valuable to all science workers. It should form an essential component in a science teacher training programme.

A science teacher who lacks this understanding is deprived of a great asset. In the author's opinion this mental skill is at least as important to the science teacher as the manipulative skills such as wood-work, glass blowing, etc.

How much useful equipment is available to a teacher depends more on the teacher's attitude towards equipment and his own resources than on the equipment itself Any approach which helps the teacher in this respect is a valuable one.

The present framework of thinking can contribute positively in this direction. It will probably prompt the teacher to approach equipment from a functional standpoint. 'Improvization' will cease to be a casual activity pursued on the basis of odd suggestions. It will come about as a result of a well-designed approach to problems relating to equipment.

The teacher who cultivates such an attitude of mind will soon come to agree that, 'the whole world is a laboratory and everything in it is equipment and material for teaching science'.

Everywhere there is an increasing awareness that it is important to provide greater facilities for teaching science and technology. This is because science and technology have produced immense changes in man's ability to understand nature's mysteries and to control and utilize its forces for his purposes. Wherever peoples are confronted with low standards of life and are trying to improve them they turn to science and technology. To implement the plans that have been prepared for the adequate teaching of science in schools and colleges is admittedly a long-range enterprise. Any guidance towards improved techniques in this field of education would surely be of great help. (For this reason Unesco is presenting a series of inventories of apparatus and materials for teaching science at all levels.)

The above words are from the preface to the Unesco series of Inventories of Apparatus and Materials for Teaching Science. The present analysis is an attempt to provide a fundamental rational basis for the construction of such lists, a framework of thinking based on the nature of science itself.

REVOLUTION IN SCIENCE CURRICULUM

DR. D. S. KOTHARI

Chairman, University Grants Commission

Four [illegible] Institutes [illegible] in Physics, Chemistry, Biology and Mathematics are being organised [illegible] jointly by the National Council of Educational Research and Training, University Grants Commission and the U.S. Agency for International Development. The object of these Institutes is to introduce science teachers to the growing frontiers of scientific knowledge and to the new methods of teaching that are being adopted in the teaching of science. The Institute in Physics was inaugurated on May 13, 1963 at Delhi University by Dr. D. S. Kothari, Chairman, University Grants Commission. We report below an extract of his inaugural address.

Perhaps, the most fundamental characteristic of our times is the large-scale and intense cultivation of science, pure and applied. In the growth of science the most significant thing is its rapid rate of expansion, its 'pace of progress'. Scientific knowledge and also things closely related to science have a *doubling period* of about 10-15 years; that is, it takes some 10-15 years for the volume of scientific knowledge and of activities or things directly linked with science to double themselves. This has been so for the last two or three hundred years. The doubling period can be estimated in several ways, e.g. from the rate of increase in the number of scientists and engineers, number of science books published in the year, number of science journals, magnifying power of microscopes, speed of aircraft, output of coal, production of electricity, number of road accidents, and so on. No matter what index we use, the doubling period turns out to be roughly the same. Frankly, we do not at all understand why the doubling period should have this value of about 15 years, and why it should have remained the same over a relatively long period. The expansion of scientific knowledge is so rapid that compared to it everything else appears to be almost stationary and unchanging. Also, though at the beginning of the 'scientific revolution' science had almost negligible impact on man's every-day life and on society, because of its extraordinarily fast rate of growth it has now come to overshadow in a sense everything else. A doubling period of 15 years is equivalent to a multiplication factor of nearly 100 over a period of 100 years. As an illustration, take the case of scientific journals. Starting with a handful of periodicals about 1750 A.D., the number rose to some 1000 about 1850, and to nearly 100,000 in 1960. It would in all probability reach a million by the end of this century. This exponential rate of scientific growth cannot, of course, continue indefinitely. Sooner or later 'saturation' must set in. In fact, the first signs of an onset of saturation are visible even today.

With this growth in the magnitude and complexity of knowledge, man's capacity to learn and absorb knowledge has remained almost the same. It does not appear to have changed appreciably since the invention of writing. There was a time when one individual—of course an exceptional one—could encompass the whole of science. But this is no longer true today. The days of encyclopaedists who knew all branches of science were over about one hundred years ago.

The growth with time in the quantity of scientific knowledge (e.g. number of science journals) is indicated by the continuous line in Fig. 1.

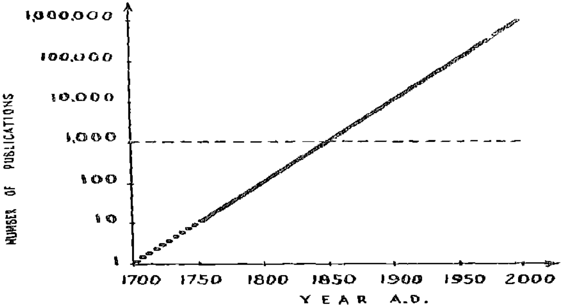

Fig. 1.

The dotted horizontal line indicates (in a crude sense) the upper limit to man's capability to learn and acquire knowledge. Notice that since about 1850 the gap between human capability and the bulk or magnitude of available knowledge is fast increasing. The only way man with his limited capabilities can cope with science expanding at a terrific rate is to fragment science into smaller units called *subjects* ; and a further fragmentation of these subjects into sub-subjects, etc. Science and technology today are divided into some 100 to 150 such subjects. This division or compartmentalization of knowledge takes place often arbitrarily, as a result of historical accidents. It is hardly possible for a person today to master even one subject. It is almost impossible nowadays to be a complete physicist. This fragmentation of science implies the great importance of cross-communication between different branches. Fragmentation is artificial, and in essence, science is a unity.

Let us turn to physics. How are we, students and teachers, to keep pace with our subject growing bigger from day to day at an exponential rate? There is so much to learn today; and there is so much more to learn with every passing year. It is apparent that we need a veritable revolution in syllabus, in methods of teaching, and in methods of learning, if we are to cope with the explosion of knowledge. In simple terms what one has to do at the school stage is to concentrate on fundamental principles only. Everything which is of passing interest, which has only a limited relevance, which does not help to broaden and strengthen understanding, can have no place in a high school syllabus. Also, these mean greater stress than has been the case in the past on mathematics as the basic tool for understanding physics. To bring about this desperately needed revolution in our syllabus—and nothing short of a *revolution* will do if our physics teaching in the schools is to profit by and fit in with the profound insight and simplification offered by relativity and quantum theory in our understanding of nature we require the combined effort of researchers, scholars and teachers in the universities and the schools. We need to establish channels of communication between the schools and the universities. The PSSC book is a magnificent effort in that direction; and we should be grateful to the band of outstanding physics teachers (from universities and schools) who gathered together and worked so devotedly to produce this splendid textbook. This book has been tried successfully in hundreds of schools in the USA. Even more important than the content of the book is the approach which it illustrates, and which is extremely commendable.

There is at present almost a revolution in the teaching of science, and this is manifest in several countries. The Science Masters' Association in the UK have also produced an excellent textbook. We must take full advantage of all the available literature from USA, UK, USSR and other countries to produce a book best suited to our own needs, conditions and requirements.

I referred to the PSSC book of nearly 650 pages (about 450,000 words). Part I of the book is entitled 'The Universe' (178 pages), Part II is on Optics and Waves (127 pages) and Part III on Mechanics (135 pages) and Part IV is on Electricity and Atomic Structure (172 pages). The part on Mechanics has a chapter of 19 pages on Heat, Molecular Motion and the Conservation of Energy. There is no mention of the specific heat of gases, calorimetry, expansion coefficients and such topics! There is no Bunsen's ice calorimeter, no Jolly's steam calorimeter. There is no mention of Gauss, Regnault or Gay-Lussac, but here we read about Maxwell, Bohr, Einstein and Planck.

A word may be said about the system of units employed in the book.

It uses the M.K.S. system instead of the usual C.G.S. system. It would be of good value if right from the school stage we introduced the M.K.S. system based on meter, kilogram, second; and ampere as the unit of current.

Another point one may mention is that of language. As Professor A.M. Taylor has pointed out in the Bulletin of the Institute of Physics (Nov. 1962) · 'The teacher cannot be effective as a teacher of science, and tolerate slovenly English. The pupil cannot construct anything of scientific value if he be unable to use the tool of language. The duty of a scientist to teach good English is as insistent as his compulsion to teach exact science I would remind you that habits of loose writing, once formed, are hard to eradicate, and worse still, blind the writer to his own faults, so that he soon becomes satisfied with his woolly inexact style, and is unable to appreciate its poverty and inadequacy as a means of communication; eventually his faults react upon him so that his thinking becomes as imprecise as his writing; even though the student may acquire a great store of factual knowledge, he fails as a scientist because he becomes unable to apply his knowledge; his powers of logical deduction are clogged by his misuse of language'.

This underscores the importance and urgency of producing for use in our schools first rate textbooks not only in English but also in the Indian languages.

It is universally recognised that good and progressive universities can only exist if we have strong and good schools. To bring this about, it is necessary that there is no unduly big gap between the universities and the schools, and everything possible should be done to bring together and to establish channels of communication between university and school teachers. A Summer Institute such as this is therefore to be welcomed from every point of view. There is no doubt that it would make a valuable contribution towards the progress of physics teaching in the country.

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NEWS AND NOTES

From the Department of Science Education

SCIENCE TALENT SEARCH

During this year the Department has launched a pilot project of Science Talent Search in Delhi Territory. The objectives of the project are to identify boys and girls of secondary schools who possess potential creative abilities in science, to stimulate scientific talent by competitive processes and recognition of merit, and to help in building up a body of future scientists who will contribute to the scientific advancement of the nation in the fields of both pure and applied science Any boy and girl studying in the final year of a higher secondary or multipurpose school, or a school which prepares students for the Indian School Certificate Examination with science and/or mathematics as optional or elective subject, and who is certified by his science teacher as being *above the average in science or mathematics* is eligible for test. The selection procedures consist of three parts—a scholastic aptitude test, an essay test, and an interview About 400 students drawn from the eleventh class of higher secondary and multipurpose schools of Delhi took the examination during this year at five different centres. The interviews will be held in the second week of July. The first 10 winners of the test will be awarded scholarships at the rate of Rs. 50 per month in the first year and Rs. 75 per month in the second and third years, the only condition being that they should join a science course in a college or university. In addition each winner will also receive a unit of science books and appliances costing not more than Rs. 100 during each year of his study in the college or university. The project will be extended to more States and Territories during the next year.

IN-SERVICE TRAINING FOR SCIENCE TEACHERS

At Dehra Dun

A four-week Summer Course for teachers of general science from Uttar Pradesh, Madhya Pradesh, Rajasthan, Punjab and Delhi was inaugurated on May 20, 1963 by Dr. K. P. Bhatnagar ex-Vice-Chancellor of the Agra University under the presidentship of Dr. P. D. Gupta. Dr. S. N. Srivastava, Head of the Department of Physics of the D. A. V.

College, Dehra Dun, is the Director of the course. Six senior science men are assisting in instructional work in the course which has science graduates as participants. The emphasis in this course is mainly on content especially on the basic and inter-disciplinary sciences.

At Hyderabad

A similar course was started at Hyderabad for the benefit of science teachers from the South. It was inaugurated on May 10, 1963 by Justice Ekbote. The Director of the course is Prof S. S. Kulkarni, Head of the Department of Botany, Vivek Vardhini College, Hyderabad. Forty science graduates from Gujarat, Maharashtra, Andhra Pradesh, Mysore, Madras and Kerala are participating in the course.

GENERAL SCIENCE SYLLABUS CLASSES I–VIII

During the year 1962-63, the Directorate of Extension Programmes for Secondary Education had prepared an integrated syllabus in general science with the help of science teachers drawn from all over the country. During the current year, this syllabus was subjected to further scrutiny by two all-India groups of science teachers. As a result of these refinements, a final edition of General Science Syllabus for classes I to VIII was prepared and has now come out of press. This syllabus is laid out under 13 broad areas of content covering Air, Water and Weather ; Rocks, Soils and Minerals ; Human Body, Health and Hygiene ; Safety and First Aid ; Housing and Clothing ; Energy and Work ; Matter and Materials ; Living Things ; Plant Life , Animal Life ; Scientists at Work ; Measurements ; and Our Universe. For each of these areas major and sub-concepts have been spelt out. This publication is now available from the Chief Publication Officer, Publication Unit, N. C. E. R. & T., 114, Sunder Nagar, New Delhi-11.

The Department has now taken up the preparation of suggested activities and experiments based on these concepts, to help the teacher in developing each of the sub-concepts. Two handbooks on activities are proposed to be brought out--one for classes I to V and the other for classes VI to VIII. It is expected that they will be available for our science teachers and readers during the year 1963-64.

SCIENCE PANELS

The panels for the writing of textbooks on Physics, Chemistry and Biology have been making active progress during these months. The panel on Chemistry textbook at its second meeting in May allotted specific areas to the different authors. A workshop at Dalhousie was planned for June-July 1963 where the authors of the Physics textbook would meet and write up the chapters.

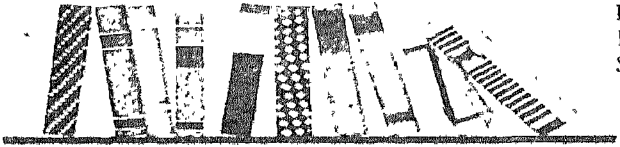
The authors of the Biology textbook have also made good progress in writing the chapters assigned to them.

PROGRAMME ADVISORY COMMITTEE

The third meeting of the Programme Advisory Committee of the Department was held on May 31 under the Chairmanship of Dr. D. S. Kothari, Chairman, University Grants Commission. The meeting discussed the science talent search, programme of summer institutes in training of science teachers ; establishment of the central workshop etc.

SUMMER INSTITUTES

The NCERT, University Grants Commission and the USA have collaborated in organising summer institutes at Madras, Poona and Delhi in Biology, Chemistry, Physics and Mathematics respectively. The object of these institutes is to introduce teachers of these subjects to the recent developments in the field and to the new textbooks and teaching materials developed in these subjects. The institutes run for a duration of 8 weeks, and offer each day two hours theory followed by practical work. They have been located at the universities at these respective places. The Director of these Institutes is a Professor and specialist in the subject. A science expert from USA, two teachers from teacher training colleges and other specialists assist in the programme. It is proposed to expand this project in succeeding years to enable more science teachers to participate in and benefit from the programme.



BOOKS FOR YOUR SCIENCE LIBRARY

Plants Today and Tomorrow : MARGARET O. HYDE

Whittlesey House, McGraw-Hill Book Company, Inc., New York, 1960

Life as we understand it now is impossible without plants because the oxygen level in our atmosphere is maintained by the activities of plants When man speculates whether living things exist on other plants the first investigation is whether plant life is possible there. Plants are essential for life, because plants provide food for man, the medicine he needs and even the oxygen he breathes. All these facts are explained in very simple language in this book *Plants Today and Tomorrow*. Plants in soil, oceans and even in space are discussed. There are not many new advances which the author has not mentioned and yet the treatment is not textual. Some of the important areas of advance handled by the author are the search for plants— low and highly advanced which yield drugs, the diseases of plants, the auxins and the growth hormones, light and its effects on plant life cycle, how to face the increased demand for food and the possibility of space gardens in space ships, which will make the traveller in space self-sufficient with regard to his food and oxygen requirements. The book thus gives a flood of information, supplemental material for the teacher, which he can use in explaining the intricacies of plant life to his students. In this way the book is very useful

S. DORAISWAMI

Elements of Biology : PAUL B. WEISZ

McGraw-Hill Book Company, Inc., New York, 1961, $ 7.50.

The conventional textbooks on any discipline of science are descriptive, full of facts which are to be memorized. Often the book will include practical applications of science related to industry, agriculture and other aspects. These were good up to a point but with the ever-increasing scientific knowledge, information memorized without understanding is likely to be forgotten soon. A first course in biology should be analytical rather than descriptive. *Elements of Biology* has been written with this aim in view. It has taken the molecule as the basic morphological unit of discussion and the molecular reaction as the basic physiological unit. Details of actual chemistry are avoided, but the orientation is molecular, i e., the student should learn to think about living processes 'from the molecule up'. As a matter of fact, the book puts greater emphasis on the molecular, cellular and community levels of biology.

Part I discusses the origin of life in sequence from atom and molecule up, the nature of all levels of living organization. These chapters are the key to the molecular orientation.

Part II deals with the nature and structure of living substance. It begins with a chapter on properties of protoplasm and the cellular organization. This is followed by types of living organisms, both plants and animals, classified into four groups

Part III is an up-to-date account of metabolism All the important reactions in photosynthesis and respiration are discussed with the aid of flow diagrams devised to make the points clear. Details of chemical equations are omitted. Modern concepts are dealt with in depth.

The next three parts deal with self-perpetuation under the headings, steady state control, reproduction and adaptation genes, vitamins and hormones ; the body fluids and nervous coordinations are some of the topics under steady state control. Reproduction in plants and adaptation genes and traits, Mendelian and non-Mendelian inheritance, the mechanism and the course of evolution are described till we arrive at the modern man

The flow diagrams and the illustrations are very instructive.

The matter presented covers all recent concepts of several processes and the book will be a valuable reference book in any school or college library

S DORAISWAMI

EVOLUTION

P. K MENON

Formerly Professor of Zoology, Presidency College, Madras.

PRELUDE TO LIFE

Evolution is still a much misunderstood subject even by the educated. To some it means that man has come up from the monkeys To the orthodox Christian it is blasphemy. To the spiritual man it is dangerously materialistic. In reality it is the obvious fact that animals and plants of today have descended from those of the past and in their long history since the beginning of life about 2000 million years ago, they have undergone change in structure and behaviour to suit the changing environment. If it is accepted that conditions of life have been changing in the long run and that animals and plants are generally adapted to live where they do, then surely they must have been changing with changing times. In other words they must have been evolving. In the process they have become more and more diverse and complex. This is the fact of evolution. Anybody who studies nature with an open mind can come only to this conclusion. As to how evolution has occurred, what have been the methods and mechanisms of change, different views have been held. Theories have been formulated, modified and even given up. But that does not affect the fact of evolution. There have been many theories as to what causes cancer. Some of them have been disproved. Even if all of them are disproved cancer will still be with us painfully. Similarly the fact of evolution is unshakable even if the theories changed like sartorial fashions. Evolution is as proved as anything can be scientifically proved. The mixing up of the theories and the fact of evolution is one of the popular confusions

Evolution is not confined to the living world. It is equally true of the non-living. The concept of evolution is as old as human knowledge. But it became a science only about a century ago in the hands of Darwin who refined it and established it on stable foundations of observed facts of nature. He also suggested a mechanism of evolutionary change which still holds good largely. Though a science in its own merit, evolution has contributions from physics, chemistry, mathematics, astronomy, geology, geography and the social sciences. These have raised evolution to the status of a universal law of nature, an all-embracing process in time and space, operating continuously, producing variety and novelty.

For about 3000 million years after the origin of the universe, roughly about 5000 million years ago according to astronomers, evolution was purely cosmic and embraced the vast universe with its millions of galaxies and millions of millions of stars and the endless space between them. The mechanism of evolutionary change was purely physical and chemical and nowhere did matter attain to greater complexity than molecules of a few atoms. In this immense process encompassing incomprehensible time and space there was nothing like a purpose as we understand purpose. Cosmic evolution was, however, a necessary prelude to life. Matter had to evolve to a certain physico-chemical condition before the complex living substance could originate. This happened about 2000 million years ago in a very restricted part of the universe. It could happen only on planets with the physico-chemical conditions conducive to the formation of large complex molecules not known outside living matter. We are certain about the existence of life only in our planet. Unlike in the purely cosmic region, in the biological sphere matter attained a higher degree of complexity. The basic constituent of living matter is protein of which numerous varieties exist.

The peculiar feature of the living substance is that it consists of molecules made of hundreds of thousands of atoms. It is due to a significant property of carbon linking up atoms in chains, rings, etc., in endless variety and great complexity. What we call life is the manifestation, (shall we say property), of this unique organization of matter. The complexity does not end there. Protoplasm, the living substance, is made up of combinations of proteins. A cell is still more complex in having organized parts like the nucleus regulating the life of the cell and attaining a unity and an individuality in itself. Protozoa are the organisms at this level. Millions of cells go to make up a higher organism which is an integrated individuality of a higher order. The multiplicity and diversity of organisms are well known. There are a million species of animals known, and about a third as many of plants. Many more existed in the past and became extinct. This diversity which is the outcome of an innate evolvability is an essential aspect of life. Change is the essence of existence. The bewildering variety of organic forms is the product of biological evolution through a mechanism not known to operate in the cosmic sphere. This mechanism is natural selection.

BIOLOGICAL

Natural selection has been as much misunderstood as evolution. Unfortunately Darwin and his immediate followers used expressions like 'struggle for existence', and 'survival of the fittest'. These were used in a metaphorical sense. They have been taken more or less literally by many and interpreted in various ways. Natural selection is the inevitable outcome of the obvious fact that some individuals leave more progeny than do others. Their type will necessarily be numerically more in the next generation If this were repeated through successive generations, that is, if the type were selected, then it will eventually form the majority of the population. A type will thus be selected if it differed from the others in a heritable and advantageous way, advantageous in the situation. That is how populations change, developing and accumulating advantageous features and thus becoming more and more adapted to the environment. Struggle for existence and survival of the fittest have no relation to evolution unless the success in the struggle and the so-called fitness lead to having more progeny which need not always be the case. So evolution by natural selection is really the differential survival of the favourable variants in relation to the environment.

Natural selection can work only on heritable variations, variations based on the hereditary material. This material is contained in the germ cells, the sperm and the ovum. They are the only organic bridge between the parents and the progeny. Each germ cell, the sperm or the ovum, has in the nucleus a definite set of delicate bodies called the chromosomes. They are big enough to be seen with the microscope. When the ovum is fertilized by a sperm, the product, the zygote, has two sets of chromosomes, one set obtained from the father through the sperm and the other from the mother through the ovum. For every paternal chromosome there is a maternal one. So there are two of every type of chromosome in the fertilized ovum. It is this fertilized ovum that becomes a new individual through the process of development involving the repeated multiplication of it into the millions of cells composing the body and the change of the cells into tissues and organs. At any division of the cell every chromosome duplicates itself and the members of each duplicate separate into the two daughter cells. The two daughter cells hence will have each two sets of chromosomes As mentioned above the germ cell has only one set, i.e., only one of every type of chromosome. This reduction is effected in the two successive cell divisions involved in the ripening of the germ cells. But for this reduction the progeny will have twice as many chromosomes in each cell as the parents. This reduction in the number of chromosomes by half before the germ cells pool their chromosomes in fertilization to start a new individual, ensures that the number of chromosomes is maintained constant in every cell of every individual of a species.

A chromosome is not a homogeneous body but a string of units called the 'genes'. A gene is a particle too small to be seen through the microscope. A chromosome may carry hundreds or thousands of genes. The genes are the units of inheritance They are made of deoxyribonucleic acid (DNA), and represent the hereditary potentialities. These potentialities are realized as characteristics when the fertilized ovum develops into the adult organism. In development the genes react with one another and with the cell substance and the environment to produce the adult individual. To go into the details of the process will be to digress too far.

Since a chromosome is a string of genes, the duplication and the separation of the chromosomes at cell divisions are really the duplication and the separation of the genes i.e., of DNA molecules. These processes are exact, but occasionally some gene or another produces a duplicate slightly different from the original ; and this may be a change in one or more base pairs in the DNA molecule. This is a 'gene mutation'. In further divisions it duplicates in the new form until it happens to mutate again. If a mutation were to occur in the germ cell, as it sometimes does, the progeny will get the mutant gene and will differ from the parents to that extent for better or for worse. This is one way of genetic change. There are possibilities of other changes during the formation of the germ cells. They get different assortments of paternal and maternal chromosomes. The chromosomes often exchange genes. There is thus a reshuffling of the hereditary material every time the germ cells are formed. As a result, no two germ cells of an individual have identical genes. In addition, fertilization is a bringing together of chromosomes from two parents. It will be seen from the above that the mechanism of heredity provides for continuity as well as change. In other words the mechanism ensures heredity and variation. So the progeny on the whole resemble the parents which is heredity, and at the same time differ among themselves and from the parent which is variation. Reproduction, heredity and variation are the primary attributes of life enabling populations to change and adapt to the environment under the operation of natural selection. That is evolution.

This technique of evolutionary change is peculiar to the living world and has been responsible for the increased tempo of evolution in comparison with that in the inorganic sphere. Fossil records show the general course of evolution. The evolutionary history of the backboned animals is clearly portrayed in the record. The story began about 400 million years ago with fish-like animals with neither jaws nor real fins. They were followed by various kinds of fish. One of the earlier of them shows the origin of the jaws from the first gill arch. Another, a little later group, had the basis of the limbs and the lungs with which they could venture into the land and become gradually adapted as the first vertebrates on land, the amphibia. Then came the reptiles out of the amphibia. From the reptiles arose the birds along one line and the mammals along another.

Two modes of evolutionary advance can be seen throughout. One is a slower process of all round advance as when the fish evolved into the amphibia or the latter into the reptiles, or the reptiles into the mammals. Each is a new form of life efficient in exploiting the more exacting environment which is progress in the purely biological sense. The other mode is the diversification of the new type so as to fit into different environmental niches. Among the fish arose forms adapted to live in the open sea, at the bottom, in the shore waters, and in the estuaries on the inland waters. The same process can be noticed in the amphibia, reptiles, birds and mammals. They radiated from a central general type and became more and more specialized in diverse ways to suit diverse modes of life. This second mode is a far quicker type of evolution. But it should be remembered that this process is only a diversification of an organization Among the mammals there are the flying, the aquatic, the terrestrial, the burrowing and the arboreal forms. They are all still mammals. So it is different from the other mode by which the fish became amphibia, the amphibia became reptilia, and so on. This is evolution of the stem form raising the upper level. The other mode is the diversification at a level. Both have gone on from the very beginning of life and enabled life to populate all the possible types of environment. An organism will be pointless apart from its environment. A population always evolves to conform with its environment as surely and as inexorably as water takes the shape of the container. The existence of any unpopulated niche provokes life to produce the appropriate form to inhabit the niche. The organic diversity is, therefore, an answer to environmental diversity.

Throughout the long history of life one can notice in the geological record changes in the environment and the consequential changes in the organic world. Natural selection was at work directing the change so as to fit the organism to the environment as explained above. Genetical changes are always fortuitous and of all kinds. They are not relevant to the situation or the needs of the organism. If some are, it is an accident. It is natural selection that gives direction to evolution by selecting the favourable variants to have more progeny, generation after generation and eventually to form the whole of a population. Of course, it takes aeons of time to bring about any substantial change to the extent of being a new species. The speed of the process depends much on the rapidity with which generations succeed. In the case of bacteria numerous generations come and go in the course of hours, so that what takes millions of years in higher organisms takes only a short period in bacteria. All of us have heard in recent times of germs becoming resistant to antibiotics. This is a simple illustration of natural selection. Among the millions of germs in a colony some may chance to have mutations advantageous in the medium containing the antibiotic like streptomycin. Whereas the others die, these survive and soon populate the entire colony. The same happens when insects develop resistance to D.D.T. These are cases of evolution under our nose.

So in the biological sector the method of evolution is natural selection. This principle of Darwin is applicable to most of the evolutionary phenomena. Evolution and natural selection are both facts of nature. Explanation of the process of evolution by natural selection is the theory of Darwin. Lamarck had another theory much earlier. It was the theory of use and disuse. According to it evolution took place by the inheritance in a cumulative way of the effects of use and disuse. To this the unconscious and passive effects of the environments on the individuals, like the tanning of the skin in the tropics, were also added later. If this could be true then evolution becomes easy to understand. In reality such effects, the so-called acquired characters, are not known to be inherited. Hence, that simple attractive theory had to be given up. Other theories involving mystical and non-verifiable factors were propounded at various times by various thinkers. They did not stand the test of science.

HUMAN

Finally we come to the human sphere of evolution. Fossil history tells us that man has been in existence for at least half a million years. It is quite certain that this history must have begun at any rate, a million years ago. Some authorities put it down earlier still. When we trace back the fossil history of man and the apes they are seen to get nearer towards a common ancestor. Man's animal origin is certain. But he has evolved into a unique animal and has attributes unknown in the rest of the animal kingdom. Further, these attributes are capable of indefinite advance and progress unlike in the case of the other animals whose progress most often led them into blind alleys and stagnation or extinction. Animals become adapted by irreversible bodily specializations that fit them like a glove in their particular environment, but make them unfit for any other. Man is capable of conscious control of the environment and so attempts to alter the environment to suit him, through tools deliberately planned and fashioned by him.

Unlike the animals man has two methods of evolution. One is biological as in the other animals through genetic change, and the other through accumulated tradition, unknown in the rest of the animal world. Julian Huxley calls it the psycho-social evolution. Biological evolution is of secondary importance in the human phase. For one thing it is very slow. The earliest known human fossil, the 'Java Man' is half a million years old. He was different from us in his smaller brain and the more beastly look in general. From that to our condition took half a million years. With adequate knowledge we may be able to speed up our evolution consciously by hundred times or more. Still a small biological change will take too long to interest man effectively. But the other method of evolution through social tradition is capable of quick result. That is where we can consciously and quickly improve ourselves. In man conscious purpose has become part of the mechanism of evolution. That is the most significant factor in the human phase of evolution Man not only evolves but can guide his evolution both biologically and psychosocially.

Heredity operates in man in the same way as in the other animals. Men vary more than most animals, because they travel longer and mix more freely so that no part of the human species has become so different as to be incapable of breeding with the rest. That is why the entire human population of the world still remains a single species. No other animal has succeeded in being world-wide and remaining one species. It is not possible to study human genetics by methods applicable to animals since man cannot be subjected to experimentation. The alternative is to study the family histories and trace inheritance through generations. This has been done to some extent. We have knowledge of a few human genes that are harmful from all points of view, like those for haemophilia and colour-blindness, to mention two well known cases. It may be thought that these could be eliminated from the human species by proper marriage systems or by sterilization of the sufferers. In fact it is not possible to eliminate them by any means; for new mutations keep cropping up in a certain frequency. But by proper mating systems their frequency can be reduced. That is the utmost that is possible eugenically until we have discovered how to prevent harmful mutations. Some genetic human defects like the two mentioned above are linked with sex so that their inheritance takes a peculiar course. Men get them more often than women. A woman shows the defects only if she gets the gene concerned from both the parents. Man shows it if he gets it from one parent. He always gets it from the mother. The father cannot give it to his son, but can give it to his grandson through the daughter who carries the gene without showing the defect, unless her mother also is colour-blind, which is very rare if at all. Obviously it is possible if we know enough of the family histories to arrange marriages so as to see that the defect does not show except, as was said earlier, when new mutuations arise. There are many other defects of which the mode of inheritance is known. It is clear that an adequate knowledge of the human genetics can help us to improve our species by reducing the frequency of the genes for certain defects.

The question logically arises, if we can reduce the frequency of the bad genes can we not equally well increase the frequency of the good ones ?

The answer is yes. But at present we have no knowledge of any such good genes. Our knowledge of human genetics is increasing rapidly. In the not very far distant future, not very near either, we may know enough about the genes for the good characteristics and traits of man and about how to produce desirable mutations to make eugenics a part of normal human practice like, say, personal cleanliness at present. But our generation shall not have to do it. At present we have no means to launch on a progressive positive eugenic programme. The matter is further complicated by the fact that we are not likely to agree on 'good' or 'bad' in a long range plan. Nor can we know what sort of man the world will want in the very distant future. Therefore at present there is little that we can do by way of guiding our biological evolution consciously.

But psychosocially man can do much. By psychosocial is meant all that man has achieved in the field of human knowledge and culture. This new factor in evolution is itself a product of evolution as it entirely depended on the special qualities of the human brain and the hand. Religion, philosophy, science, etc., that form the social and cultural heredity of man, are the products of the unique human brain and hand. Unlike biological heredity which passes from the parents only to the children through the germ cells, cultural heredity can be transmitted by anybody to anybody at anytime. It must not, however, be forgotten that this cultural inheritance of man is based on biological heredity. For the capacity to benefit by the cultural and social traditions and to make contributions to it is inborn and depends on the inherited genes. The mental faculties and the varieties of them have a genetic basis. But it is only an innate capacity. Whether it is realized or not depends on the opportunities and circumstances. Human faculties vary immensely. In fact no other species has members so varied. This is a great asset in that, the greater the variety the richer the total contributions to culture. So any system of education or training aiming at uniformity will not be able to go against human nature and progress. It is clear too that human liberty demands not only equality of opportunity but variety of opportunity. As J.B.S. Haldane has put it 'that society enjoys the greatest amount of liberty in which the greatest number of human types (genetically different) can develop their peculiar abilities'. In the animals, especially the social animals like the bees and the ants, the individuals have an inborn pattern of behaviour as soldier, worker, etc. This is genetically determined. Man on the other hand is born with plasticity of behaviour and has a long period of infancy to catch up with the traditions. Natural selection has encouraged in individuals a genetic basis which increases this plasticity as it has value in human society. The plasticity of behaviour is the basis of freedom in the true sense. The sense of right and wrong is socially acquired, and even varies from people to people Man is free to act in conformity or not. Human revolutions are instances of man acting in non-conformity. Progress often comes thus.

Evolution generated an endlessly diverse stream of things that has surged through time and space and yielded man as its finest flower. Man's evolution is in no sense over In fact the new phase has only begun. Man not only evolves but can direct the evolution of his species. His future evolution is largely in his own hands. It is within his power to choose to rise or . ... to fall.

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THE ATOMIC WEIGHTS OF ELEMENTS

R. C. MEHROTRA

University of Rajasthan, Jaipur

Although the whole fabric of science is woven around a correct evaluation of atomic weights, the title of this article will surprise many readers as to whether the subject merits any special treatment beyond the elementary textbooks of chemistry. However, within the last 2-3 years some fundamental changes have been adopted by the common agreement of the representative physicists and chemists of all the countries about this basic concept (Cameron and Wichers, 1962), and the purpose of this article is to draw the attention of students and particularly the teachers towards these fundamental changes.

With the development of the atomic theory by John Dalton, attention was focussed on the determination of precise properties of the atoms of various elements. It was for obvious reasons not possible in these infinitesimal particles of matter and hence, for defining the atomic masses of various elements, relative ratios were employed from the beginning. Thus the definition, that the atomic weights represent the relative weights of the atoms of chemical elements referred to a common standard, has held true through all these years although the 'common standard' has been changed more than once. To avoid the confusion which persists in the minds of students for a long time, it would be better to use the term 'atomic weight ratios' to emphasize the fact that we are dealing not with the absolute masses but with the numerators of ratios of the weights or masses of atoms of the respective species to the mass of an atom of a selected reference species, to which an arbitrary value is assigned by common consent as the denominator. However, the shorter term 'atomic weight' has become too well established by long usage to be changed at this stage.

Chemical Atomic Weights

As regards the reference species to be used in atomic weight determinations, the lightest gas hydrogen was the first natural choice. Early measurements of vapour densities were, in effect, atomic weight determinations, and Davy suggested in 1812 that these be expressed relative to hydrogen on a convenient numerical scale. After the acceptance of Avogadro's hypothesis, this led to the earliest atomic weight unit, H= 1.

This choice originated with Dalton and was undoubtedly reinforced by Prout's hypothesis in 1815, that atoms of all heavier elements are made up of hydrogen atoms. In the middle of the nineteenth century, newer methods, mainly based on 'oxidation and reduction', were developed for determining the 'combining weights'. These experimentally determined values of combining or equivalent weights multiplied by a suitable whole number called the valency of the element gave the values for the atomic weights for various elements. These methods of atomic weight determination, therefore, involved the combining ratio of oxygen· hydrogen. In view of the above, it was suggested by many that it might be more convenient to use oxygen itself as the reference substance for atomic weight determinations and several oxygen-based scales grew up simultaneously including those of Thomson (O=1), Wollaston (O=10) and Berzelius (O=100).

In 1885, Ostwald suggested that the atomic weight basis O=16 would combine the advantages of both types of scales. It would retain the approximate numerical values of H = 1 scale, yet it would enumerate the more precise values based on direct experimental determinations without involving the common O : H ratio. Fortunately it was fully realised from the early stages, that common agreement on this basic definition was very essential as the use of different scales by different workers would lead to a very confusing state of affairs. With the above object in view, the German Chemical Society (Landolt *et al.* 1898, 1900, 1901) circulated a questionnaire to a number of chemists in 1899 and elicited their opinions about the standard of atomic weights. The voting ran 7 for H = 1, 40 for O = 16 and 2 for 'don't know'. The Chemical Society of London also formed a committee of the foremost chemists of the day : Thorp, Tilden, Dunstan, Scott, Meldola, Crookes, Dewar and Russell, who collectively decided in favour of the scale O = 16. Realising the importance of international agreement on this subject, they suggested the formation of a committee to report regularly on atomic weights and consequently the International Commission on Atomic Weights was founded in 1902 and this later became an agency of the International Union of Pure and Applied Chemistry which is the present body representing almost all countries and their national chemical organizations. Based on this new scale, Morley and also Noyes conducted an elaborate series of very accurate experiments for determining the atomic weights of various elements. This golden era of research on atomic weights was highlighted by the award of Nobel Prize for Chemistry in 1914 to Professor T. W. Richards for his painstaking work on atomic weight determinations. The importance with which this work was viewed by contemporary chemists is evident from the fact that the above Nobel Prize award was one of the rare exceptions when it was given for improving the experimental results rather than for the discovery of new facts or ideas. With the development of more refined techniques of quartz-ware and of electrical heating, the accuracy attained even in classical chemical methods reached the limit of 1 part in 150,000. In these methods, generally the values have been obtained by determining the weight equivalence of silver with the chloride or bromide of the element in question. Another classical method which has continued to be employed is the gas density method. However, the method does not in general yield results comparable with the 'combining ratio' method discussed earlier. The criteria of 'purity' have to be as rigorous but additional corrections are essential for deviations from ideal gas properties on which Avogadro's hypothesis is based. In spite of these limitations, the method has yielded excellent results in the hands of careful workers. For example, employing the obnoxious phosphine, Ritchie (1930) derived 30.977 as the atomic weight of phosphorus which compares favourably with the currently accepted value of 30.975 (based on mass spectroscopic measurements and nuclear data).

Physical Atomic Weights

With the discovery of isotopes (species of the same element having varying atomic weights) and the development of mass spectrography by Aston, a new and rather convenient method was added to the list of chemical methods in use for the determination of atomic weights of elements. It soon became apparent that the adoption of unit weight for the hydrogen atom, and correspondingly of sixteen for the oxygen atom, were fortunate choices since they coincide with the total number of 'nucleons' (protons plus neutrons) present in the nucleus of the atom. This latter number is designated by mass spectroscopists as the 'mass number'.

The discovery by Giaque and Johnston (1929) that natural oxygen contains small amounts of isotopes of mass numbers 17 and 18 also made it clear that Aston's mass ratios were actually related to the predominant isotope of oxygen (16) and not to the natural mixture of oxygen isotopes. Ever since, the mass spectroscopists have employed the new scale in which exact number 16 has been assigned to the relative mass of the isotope of oxygen, isotope-16. The chemists, on the other hand, have continued to use the old scale in which the natural oxygen is the reference species. The effect of this variation is that the chemical atomic weights are lower than the physical atomic weights by about 3 parts in 10,000. Thus Physical Atomic Weight = Chemical Atomic Weight × 1.000275. For example, the atomic weight of the 'chemical' element oxygen is 16.0044 on the physical scale.

More accurate later work has shown that the above conversion factor

(1.000275) is also to be arbitrarily adopted. Initially this variation was thought to be negligible as is clear from the original paper of Giaque and Johnston (1929) on oxygen isotopes : 'the presence of isotopes of oxygen will, of course, not affect chemical atomic weights except in the remote possibility of non-uniform distributions'. Within a few years, however, this 'remote possibility' was proved to be significant. Following the theoretical deductions of Urey and Greift (1935), Dole (1935) showed that the atmospheric oxygen was 1.000005 times heavier than the oxygen of Michigan lake. The observed variations in the isotopic distribution of elements has thus set a limit to the accuracy with which the atomic weights of natural samples could be expressed. It has become more customary to determine separately the isotope masses and their abundance ratios. It is a tribute to the work of earlier chemists that the highly accurate data obtained from this latest technique indicated minor modifications in the case of 36 elements only and most of them were for elements whose chemistry had presented unusual difficulties or on which no recent work had been done.

Search for a New Scale of Atomic Weights

In spite of their long usage, the coexistence of two scales (chemical and physical) of atomic weights has always been considered unsatisfactory although the redeeming feature, which allowed the position to be tolerated, is that the two sets of values are used generally by distinct classes of scientists. There are occasions when inter-conversion of data becomes necessary and in this operation, mainly due to the closeness of the conversion factor to unity, there is often a tendency for mistaken confusion between multiplication and division. It has been fortunately recognised by all concerned that it would be a happier situation if the two distinct scales could be replaced by a common scale. Basically the easiest solution would have been to abandon one of the present scales, but this would have brought about a change in the accepted values by about 275 parts per million for the branch, the scale of which was abandoned. This was too big a change to be acceptable to either party particularly as the change would not be limited to atomic and molecular weights alone, but revision would be required in values of quantities such as the Faraday, Avogadro's number, and the gas constant. Various other proposals, e.g., either the neutron, the proton, or the atom of hydrogen-1, suggested themselves immediately, but a practical objection soon presented itself that such a scale would impose differences greater than unity between the mass numbers of the very heavy elements and their actual masses on this scale.

In search for a new scale, it was reasonable to choose as the reference species an element or nuclide which makes possible more direct experimental comparisons. When the oxygen scale was accepted, this consideration outweighed the logical simplicity of the hydrogen-1 scale. However, oxygen soon lost its experimental importance in comparison with silver or chlorine. The greater usefulness and fine accuracy of the mass spectrographic data directed the attention of all concerned towards some species which proves more useful in this technique. It was immediately apparent that the masses of a large number of nuclei relative to the isotope ^{12}carbon were more accurately known than the ratio of ^{12}carbon to ^{16}oxygen. The position was thus identical to the one which weighed the scales in favour of oxygen = 16 scale about six decades earlier. Fortunately, the change involved for the chemists also is comparatively much smaller and the accepted chemical values of atomic weights would be lowered as a consequence by only 43 parts per million. A joint committee of the Chemical Society and the Faraday Society consisting of Briscoe, Dunning, Emeleus, Guggenheim, Walton and Whiffen with Cahn as Secretary in U. K. recommended strongly to the International Union of Pure and Applied Chemistry (IUPAC) that this scale be accepted. Following the above and many more recommendations from different parts of the world, the IUPAC at its Munich (1959) meeting accepted this scale with the proviso that the corresponding body of physicists also accept this in their 1960 meeting. Fortunately this has been done and confirmed by IUPAC in 1961 at its Montreal meeting.

The Changes Brought about by the New Scale $^{12}C = 12$

As indicated above, the adoption of the new scale will lower the accepted values of chemical atomic weights by 43 ppm. (i.e., divide by 1.000043). Considering the 1957 Table of Atomic Weights, no value will be altered by more than 4 in the last place quoted and this is not very much as most of these have an accuracy of less than ±5 in the last figure. Avogadro's number will be reduced from $N\,(O = 16) = 6.02322 \times 10^{3}$ to $N(^{12}C = 12) = (6.02296 \pm 0.00017) \times 10^{23}$ and as is evident, the change is only about 50 per cent higher than the uncertainty in its value. It is less than one-third of the change in the accepted best value during the last 10-12 years. The gas constant R and the Faraday F will be similarly reduced by the same factor (division by 1.000043). It is thus fortunate that this change has been accepted well in time for current tables not to be affected seriously by an amount larger than the limits of error in the actual measurements. With the rapidly improving techniques and accuracy of measurements, it is feared that if it were delayed, this slight change would have necessitated much wider changes in the tables for various quantities.

The Reliability of the New Atomic Weights

The 1961 revision of the International Table of the atomic weights has not only incorporated the changes brought about by the adoption of the new scale, but advantage has been taken to review all the experimental work done since 1925 (Cameron and Wichers, 1962). As indicated above, the new scale has removed the uncertainty due to the slight variation in the isotopic composition of natural oxygen, which limited the accuracy of all atomic weights to about 1 per 100,000. This was not serious because the experimental errors involved in most of the techniques, chemical or physical (including the one based on determination of mass numbers and isotopic abundances), are greater than this limit. However, in case of 21 anisotopic (occurring in nature in only one isotopic form) elements, this was a serious limitation as the experimental work did provide values more accurate than 1 part in 100,000. The values for these 21 elements (Table I) are, therefore, given in 1961 table with a minimum of five digits representing accuracy of more than 0.0001 per cent.

TABLE I. ATOMIC WEIGHTS OF ANISOTOPIC (MONONUCLIDIC) ELEMENTS

Element	Atomic Weight	Element	Atomic Weight
Aluminium	26.9815	Niobium	92.906
Arsenic	74.9216	Phosphorus	30.9738
Beryllium	9.0122	Praseodymium	140.907
Bismuth	208.980	Rhodium	102.905
Caesium	132.905	Scandium	44.956
Cobalt	58.9332	Sodium	22.9898
Fluorine	18.9984	Terbium	158.924
Gold	196.967	Thulium	168.934
Holmium	164.930	Thorium	232.038
Iodine	126.9044	Yttrium	88.905
Manganese	54.9380		

In the case of polynuclidic elements, however, the determination of isotopic abundances seriously lowers the limits of accuracy. In the cases of seven elements (hydrogen, helium, carbon, nitrogen, oxygen, vanadium and tantalum), there is a preponderance of one isotopic form with only small amounts of the others and in such cases, more reliable results can be achieved. For other elements with complex isotope abundance ratio, the accuracy is much less. In such cases, better accuracy can be achieved by comparison with similar measurements of carefully prepared synthetic isotopic mixtures closely approximating to the natural element in composition. Such comparative measurements have been carried out so far only with boron, nitrogen, chlorine, argon, chromium, silver and uranium. For these along with the seven (with minor proportions of isotopic forms), the accepted 'best' values along with limits of variation are given in Table II. Bromine also has been included in this table as its atomic weight has been determined by chemical methods with comparable accuracy

TABLE II. POLYNUCLIDIC ELEMENTS WITH ATOMIC WEIGHTS OF HIGH ACCURACY

Element	Atomic Weight	Element	Atomic Weight
Argon	39.948	Hydrogen	1.00797 ± 0.00001[a]
Boron	10.811 ± 0.003[a]	Nitrogen	14.0067
Bromine	79.909 ± 0.002	Oxygen	15.9994 ± 0.0001[a]
Carbon	12.01115 ± 0.00005[a]	Silver	107.870 ± 0.003[b]
Chlorine	35.453 ± 0.001	Tantalum	180.948
Chromium	51.996 ± 0.001	Uranium	238.03
Helium	4.0026	Vanadium	50.942

[a]Natural variation in isotopic composition.
[b]Experimental uncertainty.

In Table III are given fourteen other elements for which the physical and chemical methods are in such excellent agreement as to lend mutual support to each other and the values, therefore, may be taken as reliable up to the last figure quoted.

TABLE III. POLYNUCLIDIC ELEMENTS FOR WHICH PHYSICAL AND CHEMICAL VALUES ARE IN CLOSE AGREEMENT

Element	Chemical value	Physical value	1961 Table
Antimony	121.75	121.76	121.75
Barium	137.35	137.34	137.34
Calcium	40.082	40.078	40.08
Cerium	140.114	140.12	140.12
Copper	63.537	63.548	63.54
Gallium	69.72	69.72	69.72
Iron	55.845	55.847	55.847±0.003[a]
Lanthanum	138.91	138.905	138.91
Lutecium	174.97	174.97	174.97
Mercury	200.59	200.61	200.59
Rubidium	85.473	85.468	85·47
Strontium	87.63	87.616	87.62
Sulphur	32.064	32.064	32.064±0.003[a]
Thallium	204.37	204.38	204.37
Zirconium	91.21	91.22	91.22

[a]Natural variation in isotopics composition.

For the remaining 33 elements listed in Table IV, the accuracy of the values chosen for the 1961 Table is somewhat uncertain and variable. The differences between the experimental values obtained by physical and chemical methods are larger than their individual apparent reliability and therefore, choice had to be made between them. For example, for six elements—cadmium, lithium, selenium, tellurium, tin and zinc—there were, determinations by at least two independent chemical methods that agreed with each other more closely than the physically determined value, and hence, the chemical values were given greater credence.

TABLE IV. ELEMENTS WITH ATOMIC WEIGHTS OF LOWER ACCURACY

Element	Atomic Weight	Method	Element	Atomic Weight	Method
Cadmium	112.40	*C*	Osmium	190.2	*M*
Dysprosium	162.50	*M*	Palladium	106.4	*M*
Erbium	167.26	*M*	Platinum	195.09	*M*
Europium	151.96	*M*	Potassium	39.102	*M*
Gadolinium	157.25	*M*	Rhenium	186.2	*M*
Germanium	72.59	*C*	Ruthenium	101.07	*M*
Hafnium	178.49	*M*	Samarium	150.35	*M*
Indium	114.82	*M*	Selenium	78.96	*C*
Iridium	192.2	*M*	Silicon	28.086	*M*
Krypton	83.80	*M*	Tellurium	127.60	*C*
Lead	207.19	*C*	Tin	118.96	*C*
Lithium	6.939	*C*	Titanium	47.90	*C*
Magnesium	24.312	*M*	Tungsten	183.85	*M*
Molybdenum	95.94	*C*	Xenon	131.30	*M*
Neodymium	144.24	*M*	Ytterbium	173.04	*M*
Neon	20.183	*D*	Zinc	65.37	*C*
Nickel	58.71	*M*			

C—Chemical Determination ; *D*—Gas Density ; *M*—Mass—Spectrometry.

An attempt has been made in the above account to present the latest position with respect to the accepted values for atomic weights of elements. Obviously, it would be desirable to seek better values for elements included in Tables III and IV and in any case, it is worthwhile to know the limitations and accuracy of such fundamental constants as atomic weights with which every worker in science has to deal continuously.

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SUN SPOTS

R. C. BHANDARI

Department of Physics, University of Rajasthan, Jaipur.

The sun needs no introduction. For centuries, a fire-ball has been rising in the east and disappearing in the west, giving heat and light to earth. The quest for knowledge led to the careful observation of the sun. It was in 28 B.C. that the Chinese first observed through the naked eye some 'black' patches, which they attributed to be some 'flying birds' across the solar disc. Thus the centuries-old belief in the sun's unblemished purity was challenged. Galileo with his self-made telescopes observed the sun and after a large number of repeated observations propounded that these are dark patches on the surface of the solar disc. These patches are termed sun spots.

The birth and death of a sun spot or a group of sun spots is an unsolved riddle till today. Once they appear on the disc, it has been found that they are taken round the solar disc, where they progress. This sort of behaviour has confirmed the sun's rotation period to be 27 days. Rapid development and slow decline characterise the life history of a spot During the growth the size varies. Some spots are very tiny, others so big as to be easily visible to the naked eye, in a hazy background. A spot or a group to be visible to the naked eye should be 25,000 miles or more in diameter. Besides the size, the number also varies. This variation continues from day to day and even from year to year. In some years the number is a maximum while in others it is a minimum. It is possible that for some days in a year the sun may exist perfectly pure, that is spotless. The interesting part of this maximum to minimum variation is that it shows a periodicity. The span of a maximum to minimum on the average has been found to be 11.2 years. During a maximum the largest spot or a group may last 3 to 4 months.* Between 1749 and 1958, the largest number was observed in 1957.

Like the sun, the spots affect the earth and its atmosphere. A tree trunk is found to have concentric rings of varying thickness. The rings are a measure of the age of the tree. The surprising feature is that the rings show a periodicity in their thickness. The 11-year variation of thickness has been attributed to the 11-year cycle of sun spots. Though no other detectable effects on the earth's atmosphere has been observed, it has been taken that during sun spot maximum more wood grows and hence the rings are thick. C E P. Brooks, an authority on the subject of weather periodicity, claims that the matter of 11-year sun spot cycle suggests that at the sun spot maximum the earth is cooler, rainier and more stormy than at times of minimum. Likewise, the magnetic storms accompanied by beautiful Auroral display in both the hemispheres is due to the atoms or electrified particles shot out from the sun spots and occasionally by other solar activities. It is believed that cosmic rays also originate in such solar activities.

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* The largest group of 1946 was 200,000 miles long with a spot 60,000 to 90,000 miles long. The group had a maximum area of 5,700 million sq. miles and lasted for 99 days.

The spectroscopic study has opened another secret about these spots. It has been found that these spots are seats of large magnetic fields. These fields, in the largest spot, are several thousand times stronger than the earth's magnetic field. The spectrum of the sun spot has been a measure of the temperature. The temperature of the spots has been estimated to be about 4000°C. Due to this high temperature, though less than that of the rest of the surface of the sun, the spots radiate heat and light like the sun. But in the highly intense background at 6000°C, the intensity of light from the spot is much less and hence they are 'black'.

The cause of sun spots is still speculative. Scientists, in different parts of the world, are working along this direction. G E. Hale in America suggested that the spot is the top of a column of very hot gas coming up from below the surface of the sun. As the gas rises it is set whirling and the vortex motion of electrified material produces a magnetic field. As soon as it reaches the surface where the surrounding pressure is reduced, it expands and is thereby cooled causing the dark spot. Hale could thus explain the cause of magnetic storms and display of Aurora. Recently, Professor Alfven of Sweden has advanced a theory based on hydrodynamic processes. He assumed that strong magnetic fields exist inside the core of the sun and ionized gases flow through such fields. Dr. Alfven claims that due to some instability, perhaps by convection, magnetohydrodynamic waves are propagated outside from the central region, carrying some field of the interior along with them. These waves are guided by the magnetic lines of force and on reaching the photosphere emerge as a spot. Alfven's theory is being examined in the light of results obtained with the help of mighty telescopes. The study of sun spots and associated phenomena is, thus, far from complete.* It is possible that some day in the future with the rapid growth of scientific and engineering technique, the birth and death of the spot will be explained satisfactorily.

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* It is expected that the sun is arriving at its minimum level of activity in 1964-65 Like IGY it is planned to organise 'The International Year of Quiet Sun' 1964-65 (IQSY). During this period it is hoped that more data will be available to understand the mysterious spots.

ALGAE IN OUR LIVES

S. DORAISWAMI

Department of Science Education

National Council of Educational Research and Training, Delhi.

The word algae to the uninitiated means pond-scum—the green floating material in waters of ponds, lakes or even ditches by the side of roads. But to a knowledgeable person, algae are plants belonging to a large class which is the lowest and simplest in organization. This group is called Thallophyta which really means plants with a thallus or body, undifferentiated into stems and roots. This definition is not correct because some of the giant sea-weeds—kelps—are so huge and long and are fixed to the rocks or the bottom by means of a stipe, and have leaf-like floating structures on stem-like portions. These sea-weeds are also algae.

Algae are essentially aquatic occurring both in fresh-water and in the sea. Any small piece of water is enough to support the growth of some green scum. Even the spray from tides, breakers or waterfalls or even the dripping from a leaky tap gives enough moisture to support algal growth. Algae occur in warm climates and in cold climates, on snow and some even in hot springs. There are algae in the soil and on tree trunks; they occur as parasites and on walls of houses ; and they even attack tent cloth in some moist countries. They are ubiquitous.

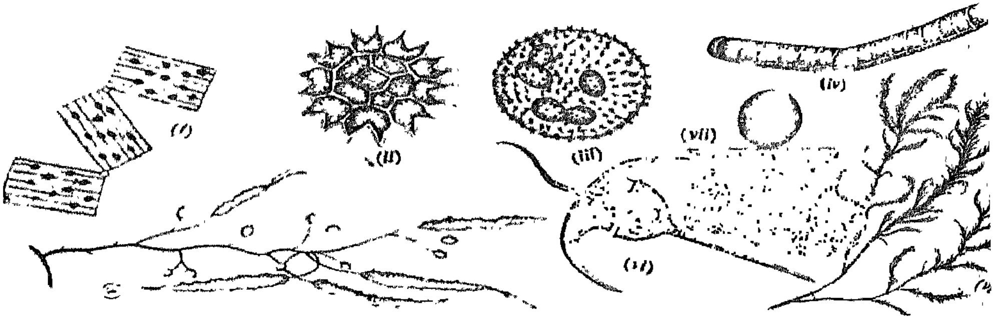


Fig. 1. A few Algae.

(*i*) *Diatoms* ; (*ii*) *Pediastrum* ; (*iii*) *Volvox* ; (*iv*) *Oscillatoria* ; (*v*) *Sargassum* ; (*vi*) *Ceratium* ; (*vii*) *Botrydium* ; (*viii*) *Dasya* (Red alga)

Many consider these plants useless and some even consider them as a nuisance. But it is not so. In the following pages it will be shown how useful they are to us.

Algae are of many kinds having different colours. The green ones are the most common, and the brown and red varieties are common in the sea. A fourth group—the blue-greens—are found everywhere particularly in dirty waters. All these plants possess the green pigment, chlorophyll, and can prepare their own food, utilizing the energy from the sun. Besides the green pigment some algae also have an orange pigment, (carotene), yellow pigment (xanthophyllz) and the phycobilins (proteinaceous) which contains the blue phycocyanin and the red phycoeyrthrin. The colour of the algae is due to the predominance of one or the other of these pigments. It is their power to manufacture carbohydrates and their ubiquitous nature that give these plants their importance. They are primary food makers and have been preparing food for ages, long before any other complicated form of life did. Indeed many of the latter have been dependent upon algae for their food. The food prepared by these represent so much of bottled energy. Some algae can even store food in the form of oil which fact again has very great importance.

Thus these lowly organisms—algae—ranging in size from microscopic forms to huge sea-weeds are very important to man and animals. They are our friends.

ALGAE IN THE FOOD CHAIN

Algae occur sometimes as attached forms, but largely as free-floating forms known as plankton. Almost any type of aquatic situation like sea, oceans, lakes, ponds, rivers and streams abound in phytoplankton. They may be isolated individuals or in the form of filaments or groups as colonies. The plankton is the only vegetation in the open sea where no other vegetation occurs. The animal population in the open sea is also great. How and wherefrom do these small animals and fish get their food ? It can be only through the plankton, which are the primary food-makers in these waters. The plankton is the primary and basic link in the food chain. Algae, both plankton and attached forms, in the sea and in fresh-water, provide the primary food for fish and other aquatic animals. Algae serve the need of fish both directly and indirectly. There is an old Chinese proverb which on translation runs thus :

Big fish eat little fish
Little fish eat shrimp
Shrimp eat mud

It is common knowledge among biologists that shrimps eat smaller animals which again feed on still smaller animals or on decaying vegetable matter, which perhaps is the mud referred to above.

Many food chains start with algae and proceed through copepods, crustaceans, small fishes, big fishes and eventually man. An examination of the stomach contents of gizzard shad or tadpole would reveal abundant plankton forms. Many aquatic animals live partly or wholly on algae. The gizzard shad eats up large quantities of plankton, and this fish is in turn eaten by bigger game fish. Another common chain is hake feeding on herring, herring on copepods, and copepods on diatoms. The oyster depends upon available diatoms while the California sea-mussel prefers a mixture of dinoflagellates and diatoms. *Catla catla* is a plankton feeder. Since plankton serves as food to many fishes, it should be possible to keep the water sufficiently stocked with algal material for the fishes cultivated in it. These waters can profitably be manured in order to get better fish yield. In Philippines the fry of milk fish are taken from the sea and cultured in fish ponds with *Lyngbya aestuarii*. This alga serves as baby food for the fry for three months after which they are fed on *Cladophora* and *Chaetomorpha* in another tank. A few months later they are fed on *Enteromorpha* in a third tank. For raising fry, first the pond is manured. This gives rise to a rich phytoplankton and this is followed by one of zooplankton consisting of rotifers, copepods and *Cladocera*. The fingerlings use both the plants and the animals.

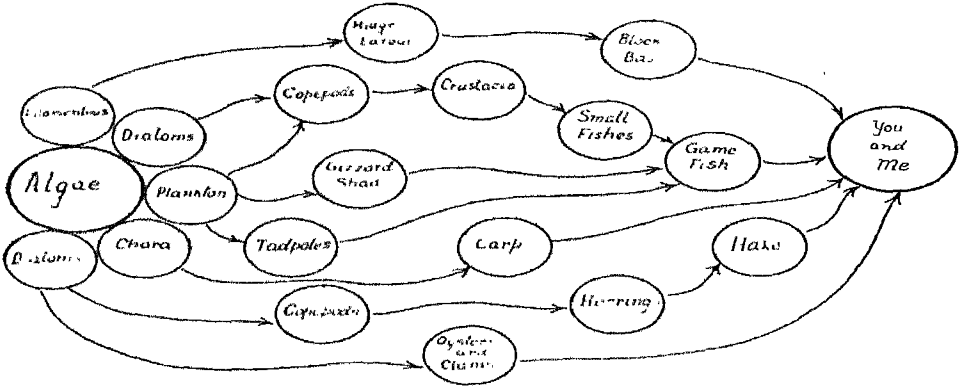
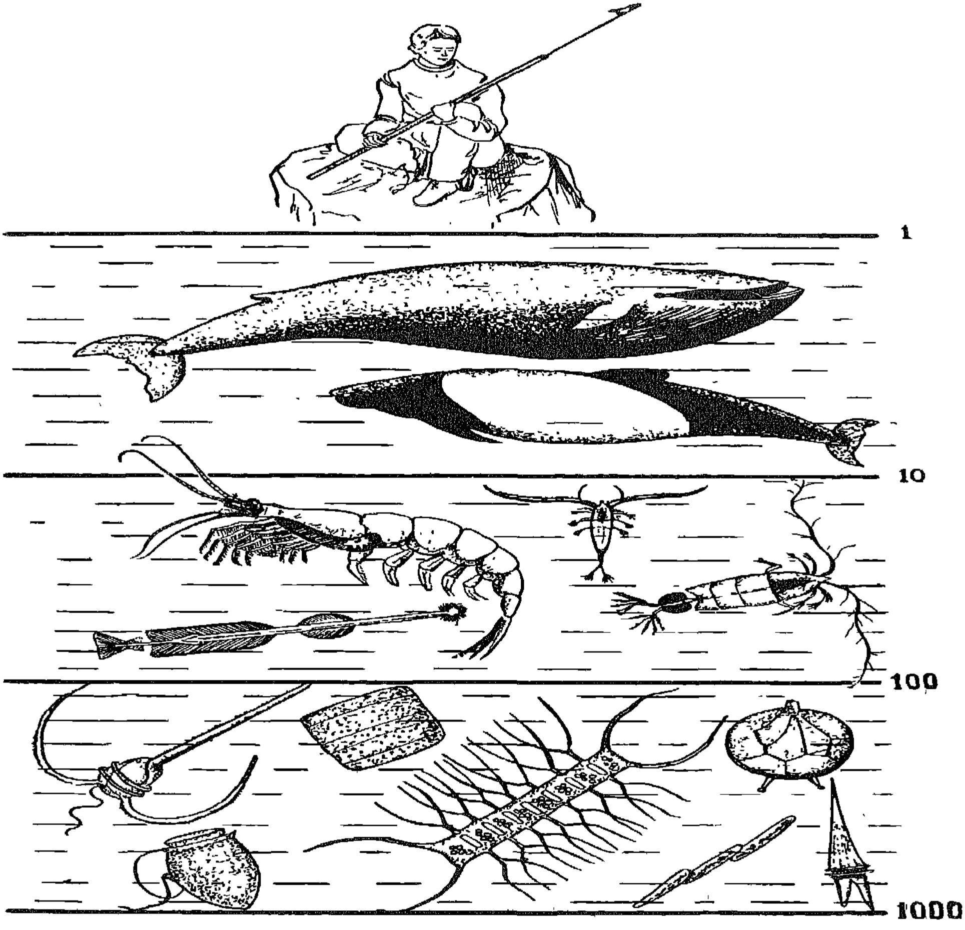


Fig. 2. Algae in Food Chains. (after Tiffany, L.H. 1958)


1
10
100
1000

It has been noted that in the Malabar Coast there is a close correlation between the migration of sardines and diatoms. Sardine landings are big soon after a bloom or during the height of a bloom of *Fragilaria oceanica* -a diatom. As a matter of fact the fluctuation of this diatom can be used as an indicator of the abundance of oil sardine. The oil sardine fishery starts with the commencement of the *Fragilaria* bloom.

The plankton, besides being food of the animals, also act as oxygenators of the water. Oxygen is very essential to the existence of fish, and carbon dioxide in certain concentrations is lethal to fish life. By their ability to photosynthesise, the plankton use up the carbon dioxide and liberate oxygen into the water. Thus the balance of oxygen and carbon dioxide in the water is kept up.

The number of algal cells in a cubic centimeter of water is so much that when they die, there is a regular shower of plankton cells sinking to the bottom adding organic matter which is used as food by the bottom dwellers.

ALGAE AS FOOD

Perhaps many people will appear sceptic if you tell them that algae can be used as food. They may even show a feeling of aversion at the mention of the word algae which to the popular mind connotes 'pond scum'. But the use of sea-weeds as food is quite widespread and it has been used in the East from time immemorial. The Chinese and the Japanese use a greater amount of sea weed as food than any other people. Other people also like those of Indonesia, Burma, Siam, Borneo and Malaya ; use sea-weeds directly as food.

The Japanese eat *Porphyra*, called *amanori* which is even cultivated on a large scale. They sink bundles of bamboo into muddy bottoms of water. The spores of algae lodge on these bamboos and grow rapidly into adult plants within 3 or 4 months, when they are harvested. The French and the British boil it for hours to make a sauce-like preparation. The broad forms of sea-weeds or kelps (*kombu*) constitute an important food product. Japan exports large quantities of *kombu* to China. *Amanori*, *kombu* and *tenguse* (*Gelidium*) are important Japanese edible sea-weeds.

Ulva lactuca was used in Scotland for salads and soups ; and *Laminaria*, *Rhodymenia* and *Porphyra* in Scotland and Ireland.

In Hawaii *limu*—a group of sea-weeds—is sold in large quantities. *Durvillea antartica* and some *Ulva* are used in Chile. Fresh sea-weeds are used as food only in China and Japan.

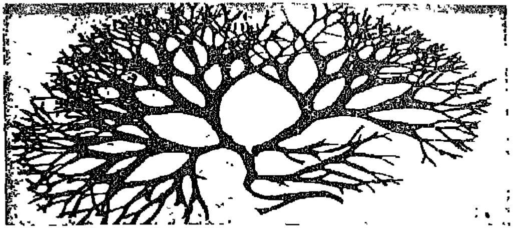
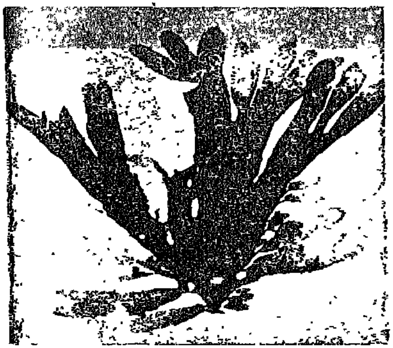


Fig. 4. *Chondrus crispus* or Irish moss.

Fig 5. *Rhodymenia* or dulse.



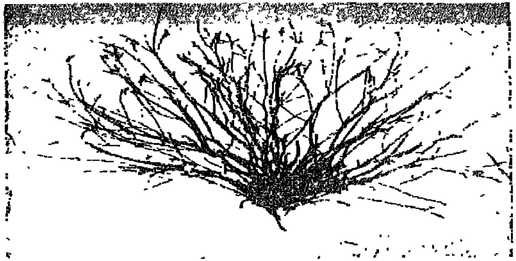


Fig. 6. *Gelidium*, red alga from which agar is obtained.

TABLE I. FOOD VALUE OF SOME ALGAE

	Water %	Raw Protein %	*Fat* %	Starch and Sugar %	Fibre %	Ash %
Nostoc commune	10.6	20.9	1.2	55.7	4.1	7.5
Ulva lactuca and *U. fasciata*	18.7	14.9	0.04	50.6	0.2	15.6
Laminaria spp	23.5	5.85	1.15	41.95	6.7	21.1
Porphyra	17	28	0.8	40.1	—	10.3

(after Chapman, V. J. 1960)

In South America, a blue-green alga like *Nostoc* and some sea-weeds are boiled along with other vegetables to add flavour.

The food values of some algae are shown in Table I. *Porphyra* among these has a higher protein value. But sea-weeds as such are not a good source of energy. A large portion of the calories they contain are in an indigestible form. But the sea-weeds can be consumed along with other food. Their nutritional value depends upon their vitamin and mineral content.

Marine algae are a rich source of vitamins, particularly A, B, C, and E. Some plankton forms like *Nitzschia* are rich in vitamin A and the cod fish gets most of its vitamin A from a feed of *Nitzschia*. *Ulva* and *Porphyra* are rich in vitamin B. Some sea-weeds have as much vitamin C as lemons, and the vitamin B content of some compares favourably with that of many fruits and vegetables. The vitamin content of a few sea-weeds are given below.

	Vitamin C (mg/100 gm fresh water)	Vitamin B (Sherman units)
Alaria valida	53	250
Laminaria spp.	53	200
Porphyra nereocystis	6053	550
P. perforata	60	500
Porphyra sp.	140	500

Porphyra is used as a source of iodine, which is very important for the normal functioning of the thyroid gland. Goitre is not known in Japan or China because the people get their iodine from the sea-weed in their diet. According to Tilden, the sea holds for man the solution for many deficiency diseases.

Mass culture of algae for food : It has been known for a long time that algae are potential sources of food and energy, if they could be economically harvested. During the last few years attempts have been made to grow algae in mass cultures under experimentally controlled conditions. The leading persons working successfully on this culture work are Harder, Von Witsch Mayer and Tamiya. The rapid and controlled growth of single celled algae led to the idea that they might be cultured for food purposes in a controlled environment. It has been shown that it is possible to grow algae like *Chlorella* and *Scenedesmus* in large quantities. But at present such methods are proving expensive.

Dried cells of *Chlorella pyrenoidosa* have a high vitamin content, 50 per cent of protein and many useful amino acids. With the present knowledge of technique it is possible to keep up a high productivity of algal culture. Pilot scale *Chlorella* farms have already been established in America, Holland, Germany, Israel and Japan.

The cultures are made in two ways. In one the alga is grown in polythene tubes on roof tops of big buildings. This method does not require cultivated land and it is not at the expense of existing fields intended for crops. The other method is to culture *Chlorella* in large shallow tanks where the contents are stirred by mechanical means and given additional carbon dioxide. A uniform suspension is maintained by periodical removal of algal mass already grown. The algae are then collected by centrifuging and processed to a dry powder. In this process it is also de-chlorophylled in order to get a white powder. This powder is eaten in various ways. It is good when mixed into ice cream or added to the flour when making bread. For some, the taste is not so pleasant but to others, its vegetable taste is pleasant. Japan has the technical skill, and the economic conditions there are such as to make mass culture a commercial success.

In such cultures a yield of 3½ tons of dry matter per acre is possible. This is far too high when compared with the yield of any cereal. In the cereals only the grains are used and the other parts are not fit as human food. In algae the whole plant can be used. Cereals can be grown only in certain seasons but algal cultures can be continuous.

It may take many years more before men could be coaxed to change their food habits to include algae, but it is within human possibility to produce enough material and convert it into a more palatable form. According to Tamiya, sooner or later industrialization of algal mass culture will be realized. Even now, it has great potentiality to become supplementary human food and poultry feed.

Space farms : In this age when space travel by astronauts is becoming common, interest in using algal cultures to supply food as well as oxygen is increasing. Controlled cultures of *Chlorella* on a smaller scale could be used for food, and for replenishment of oxygen in inhabited space ships and submarines. The problem of keeping up an exact balance between the carbon dioxide and oxygen in the atmosphere of a closed system containing a culture and a man is not so simple. The cultures must be so controlled that the volume of carbon dioxide produced per volume of oxygen used up is as near unity (1 0) as possible. Scientists will have to think of some such arrangements for large-scale rocket and space travel programmes.

ALGAE AS FODDER

Sea-weeds are used as fodder in many countries. In the Scandinavian countries, cattle and sheep graze selectively on *Rhodymenia* (*R. palmata*) at low tides. The weeds are gathered and washed in fresh water. There are factories set up here, where the sea-weeds are processed as stock-feed for cattle, poultry and pig. The sea-weed meal is used for its protein content and it is reported that dried sea-weeds when fed to cattle and poultry increase their milk yield and egg-laying capacity. The sea-weed compares well with other feeds (Table II).

TABLE II. COMPOSITION OF SOME CATTLE FEED

Dry material	Water	Protein Raw	Fat	Ash	Fibre	Carbohydrate N free extract
		(in percentage)				
Sea-weed	10.0	6 2	3 8	15.1	3 5	61 4
Good hay	14 3	9.7	2.5	—	26 3	41 4
Potato tops	—	7.27	0.37	—	2.75	84 49

In India where most of the cattle population is in a poor condition, this usefulness of the sea-weeds could be exploited. The sea-weeds, either fresh or suitably treated, may be utilized as cattle food in the coastal areas.

ALGAE IN AGRICULTURE

Algae are part of the micro-organisms found in the soil. The others are bacteria, fungi and protozoa. It is only the algae and some chemosynthetic bacteria that can prepare food. According to Russel one gramme of manured soil has one million algae of which the blue-greens are the dominant ones. Most of these are found in the upper 6 inches of the soil. Some diatoms and blue-green algae may occur in deeper layers. The soil algae are of importance in freshly formed soil. They liberate oxygen during

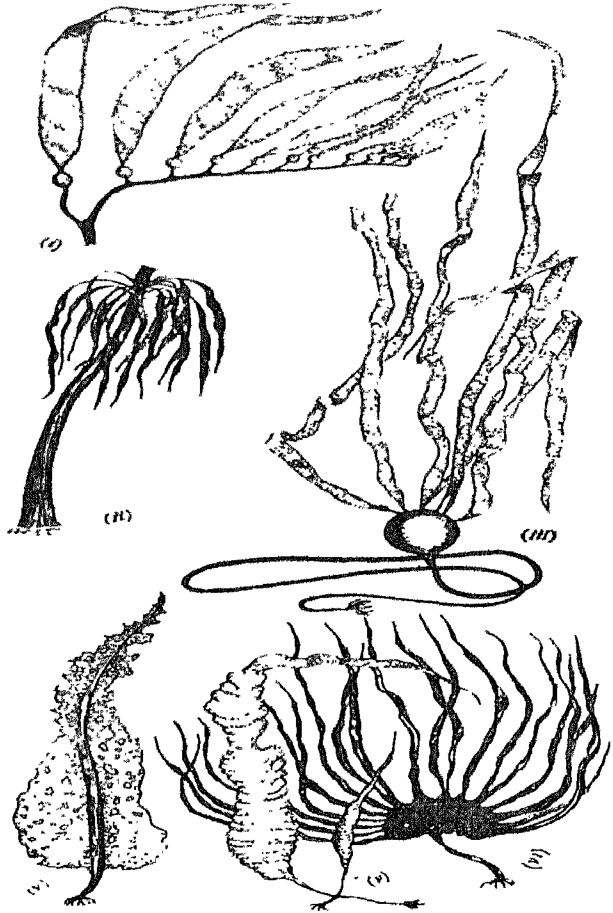


Fig. 7. Some sea-weeds.
(i) *Macrocystis* ; (ii) *Postelsia* (sea palm) ; (iii) *Nereocystis* ; (iv) *Agarum* ;
(v) *Laminaria agardhii* ; (vi) *L. digitata*.

the process of photosynthesis and they add organic matter after death. The presence of numerous algae in the water-logged condition of rice fields is significant in this respect. Apart from their reported capacity to fix atmospheric nitrogen, these algae are also supposed to add oxygen to the water.

Nitrogen fixation : It is now fairly well established that the blue-green algae can fix atmospheric nitrogen even when not associated with any bacteria. About 8 to 20 species have been proved to fix nitrogen. These belong to the genera *Nostoc, Anabaena, Cylindrospermum, Calothrix, Tolypothrix, Anabaenopsis* and *Mastigocladus.* In tropical soils, these algae are of great importance in maintaining fertility. A rich growth of algae in the water-logged rice fields in our country is a common feature. There is evidence to show that these algae help in maintaining the fertility of the rice fields. The fixation of nitrogen takes place only when combined nitrogen sources are absent or are in low concentration. The algae must be in an actively growing stage These algae have a high nitrogen content. On bacterial decomposition, the algae release ammonia readily and this becomes available to the plant

Japan utilizes these algae on a large scale. As a result of applying the nitrogen-fixing *Tolypothrix tenuis* (2-10 lbs. of dry weight per acre), Watanabe got an increase in the yield of rice The increase was 2.7 per cent in the first year, 8.4 per cent in the second year and 21.8 per cent in the third year. He found that inoculation with this alga was equivalent to manuring the field with 64 lbs. of ammonium sulphate per acre as additional fertilizer. Similar and encouraging results have been obtained by experiments in India. The growth of the nitrogen-fixing blue-green algae is encouraged by the addition of lime and phosphates. For inoculation, the algae with their clay substratum is made into granules These dry granules can be broadcast in the field

Reclamation of usar *lands* In parts of India the soils are alkaline (*usar*) with deposits of salt. Such soils are not suitable for crops. Two methods are adopted in reclaiming such *usar* lands. One is the chemical method of adding organic matter in the form of farmyard manure or green manure along with gypsum. The other method is to encourage algal growth on these lands in successive crops. After such growths under water-logged condition, it has been shown that the pH is reduced from 9.7 to 7.6. The nature of soil is improved and water-holding capacity becomes 40 per cent. The algae provide the organic matter. By the growth of the algae the sodium clay is converted into the calcium type Increase in paddy yield is claimed in such reclaimed soils

Sea-weeds as manures Sea-weeds may be applied directly or in the form of composts. The direct application is practised in many countries like Eire, Isle of Man, Japan, China and Ceylon for manuring potatoes, cabbage, turnips, cauliflower and rice as well as coconut and coffee plantations. Sea-weeds are rich in potash, ionic sulphates, trace elements and other important substances required by the crop plants. At the central Marine Fisheries Research Station, Mandapam, a compost from *Hypnea* has been tried. The application of this compost was found to increase the yield of some vegetables, tapioca, papaya, etc. India has an extensive coastal belt and an exploitation of these natural resources will provide the farmer with an ample supply of manure.

ALGAE IN WATER BLOOMS

Sometimes when the conditions are favourable for the growth of algae, dense masses of them are formed on water giving it a colour. Such growths are known as *water blooms*. We find such blooms very often in rain water puddles and in temple tanks where they constitute a nuisance. The Red Sea has derived its name, paradoxically enough, from the occurrence of water blooms of a blue-green alga, *Trichodesmium erythraeum*. The most obnoxious forms are *Microcystis flos-aquae* and *M. aeruginosa*. Water blooms not only give foul smell and taste but prove undesirable in fishery ponds. Blooms even cause the mass death of fishes. At night the algae and animals use up all available oxygen in the water and early in the morning dead fish are cast ashore. The decay of the plants further reduces the oxygen content. Another cause for the death of fish is by the physical choking up of gills by the bundles of filaments of algae. There is also evidence to show that some forms exude toxic substances which bring about the death of fishes, or some animals, which drink such bloom-infested waters. A dinoflagellate, *Gymnodinium*, has also been reported to have caused mass mortality of fish. The 'red tides' in the Gulf of Mexico are due to *G. brevio*. These tides caused the death of more than 200 million lbs. of fish during 1946-1947 in Florida. The toxins have two factors in them—a slow death factor (SDF) and a fast death factor (FDF).

The most common method of controlling the water bloom is by the application of copper sulphates in doses not harmful to animals and man. Shading of the water is another method. A cover of *Lenna* limits the growth of the bloom. Later *Lenna* can be removed.

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PROFESSOR MEGHNAD SAHA (1893-1956)

PROFESSOR MEGHNAD SAHA MEMORIAL LECTURE*

D. S. KOTHARI

Chairman, University Grants Commission

I consider it a privilege to be invited to give the *Saha Memorial Lecture* under the auspices of the Indian Physical Society. Inadequately qualified as I certainly am for this task, I nevertheless deeply appreciate the honour of speaking on this occasion.

I propose to speak mainly about some aspects of Professor Saha's life and work. His career and his contribution to knowledge and to society cover such a wide and varied field that it is not possible to present them even in a summary form within the compass of a single lecture. I am also conscious that much of what I have to say is already familiar to many of you, and many of you, in fact, know more about him and his work than I do. All the same, to remind ourselves of his life and great example, even though briefly, is to enrich our lives in no small measure.

The name of Saha would always remain associated with the theory of high temperature ionization and its application to stellar spectra. Apart from astrophysics, the theory has found numerous other applications such as, to mention some of them, in the study of the ionosphere, conductivity of flames, electric arcs and shock waves. Saha's theory had all the simplicity and inevitableness which characterise a fundamental and epoch-making contribution. It was almost a direct consequence of the recognition that the laws of classical thermodynamics and the kinetic theory of gases can be extended to a gas of free electrons. Saha's researches in physics and astrophysics covered a wide range of subjects. He worked at one time or the other on stellar spectra, selective radiation pressure, atomic spectra, molecular dissociation, ionospheric propagation, radio waves from the sun, solar corona, beta-radioactivity and age of the rocks. Besides physics, he took keen interest, almost bordering on the professional, in ancient history and archaeology.

He was from the beginning a member of the Council of Scientific and Industrial Research constituted by the Indian Government in 1942, and member (or chairman) of several of the research and other committees of the Council. He was the Chairman of the Council's Indian Calendar Reform Committee.

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In his criticism of things and men, Saha was fearless and trenchant, and he was always motivated by a deep earnestness, and sincerely, though often tenaciously, held convictions. His memory and versatility were amazing. He was extremely simple, almost austere, in his habits and personal needs. Outwardly, he sometimes gave the impression of being remote, matter of fact, and even harsh, but once the outer shell was broken, one invariably found in him a person of extreme warmth, deep humanity, sympathy and understanding; and though almost altogether unmindful of his own personal comforts, he was extremely solicitous in the case of others. He was a man of undaunted spirit, resolute determination, untiring energy and dedication.

Saha was a keen student and ardent advocate of social and economic planning in India, particularly in its relation to science, large-scale industry and technology. He was an active member of the National Planning Committee appointed by the Indian National Congress in 1938 with Shri Jawaharlal Nehru as Chairman. His general philosophy in these matters is perhaps best expressed in the following words taken from an article of his published in *Nature* (1945): 'The philosophy of kindliness and service to our fellow-men was preached by all founders of great religions, and no doubt some great kings and ministers of religions in every country and at all ages tried to give effect to this (altruistic) philosophy. But the efforts were not successful, for the simple reason that the methods of production of commodities were too inefficient to yield plenty for all, which is an indispensable condition for practical altruism. We can, therefore, hold *that so far as individual life is concerned*, science has achieved a target aimed at by the great founders of religions in advanced countries of the world. The effects of maldistribution of wealth, due to historical causes, are being rapidly cured by the introduction of social laws.'

The life of Saha was in a sense an integral part of the growth of scientific research and progress in India, and the effect of his views and powerful personality would be felt for a long time to come in almost every aspect of scientific activity in the country. His dedication to science, his forthrightness and utter disregard of personal comforts in the pursuit of his chosen vocation will long remain an inspiration and an example. On February 16,1956, on his way to the Office of the Planning Commission in New Delhi, he succumbed to sudden heart attack (some hundred yards from the office of the Commission), and at the age of sixty-two, a career superb in science and great in its promotion and dissemination was tragically closed.

Saha's greatest contribution is, as already mentioned, the theory of high temperature ionization. The equation that goes by his name was first given by him in his classical paper, 'On Ionization in the Solar Chromosphere' which appeared in October 1920 issue of the *Philosophical Magazine*. He, using the language of physical chemistry, called the equation the 'equation of the reaction-isobar for ionization'. The theory provided, for the first time, on the basis of simple thermodynamic considerations and elementary concepts of the quantum theory, a straight-forward interpretation of the different classes of stellar spectra in terms of the physical conditions (temperature and to a lesser extent pressure) prevailing in the stellar atmospheres. To quote from S. Rosseland's introduction to his well-known *Theoretical Astrophysics* (Oxford University Press, 1936) : 'Although Bohr must thus be considered the pioneer in the field, it was the Indian physicist Meghnad Saha who (1920) first attempted to develop a consistent theory of the spectral sequence of the stars from the point of view of atomic theory. Saha's work is in fact the theoretical formulation of Lockyer's view along modern lines, and from that time the idea that the spectral sequence indicates a progressive transmutation of the elements has been definitely abandoned. From that time dates the hope that a thorough analysis of stellar spectra will afford complete information about the state of the stellar atmospheres, not only as regards the temperature and various deviations from a state of thermal equilibrium, but also the density distribution of the various elements, the value of gravity in the atmosphere and its state of motion. The impetus given to astrophysics by Saha's work can scarcely be overestimated, as nearly all later progress in this field has been influenced by it and much of the subsequent work has the character of refinements of Saha's ideas Truly, Saha's work ushered in a new epoch in astrophysics.'

It is pertinent to remark at this stage that ionization theory was formulated by Saha working by himself in Calcutta, though erroneous statements have sometimes appeared to the contrary. The paper referred to above was communicated by him from Calcutta to the *Philosophical Magazine*, London. Saha's first visit to Europe was made a couple of months later. We shall describe in Saha's own words how he was led to the ionization theory. I quote from a letter of December 18, 1946 which he wrote to Professor H. H. Plaskett of the University Observatory, Oxford : 'It was while pondering over the problems of astrophysics, and teaching thermodynamics and spectroscopy to the M. Sc. classes that the theory of thermal ionization took a definite shape in my mind in 1919. I was a regular reader of German journals, which had just started coming after four years of the First World War ; and in the course of these studies, I came across a paper by J. Eggert in the *Physikalische Zeitschrift* (p. 573), December 1919, 'Ueber den Dissoziationzustand der Fixsterngase' in which he applied Nernst's Heat Theorem to explain the high ionization in stars due to high temperatures, postulated by Eddington in the course of his studies on stellar

'Eggert, who was a pupil of Nernst and was at the time his assistant, had given a formula for thermal ionization potential of atoms, the importance of which was apparent from the theoretical work of Bohr, and the practical work of Franck and Hertz which was attracting a good deal of attention in those days . . . . Eggert used Sackur's formula of the chemical constant for calculating that of the electron, but in trying to account for multiple ionization of iron atoms in the interior of stars on these bases, he used very artificial values of ionization potential.

'While reading Eggert's paper, I saw at once the importance of introducing the value of *Ionization Potential* in the formula of Eggert, for calculating accurately the ionization, single or multiple, of any particular element under any combination of temperature and pressure. I prepared in the course of six months of 1919 (February to September) four papers and communicated them for publication in the *Philosophical Magazine* from India within August to September.' Saha in his paper 'On Ionization in the Solar Chromosphere' makes a handsome acknowledgement to Eggert's work.

One of the four papers above referred to was 'On the Harvard Classification of Stellar Spectra'. When shortly after communication of the paper Saha went to London, he withdrew it from the *Philosophical Magazine* and completely rewrote it in Professor Albert Fowler's spectroscopy laboratory in the Imperial College of Science and Technology, London. The revised (and, no doubt, considerably expanded and improved) paper was published in the *Proceedings of the Royal Society* (1921) under the title, suggested by Fowler, 'On Physical Theory of Stellar Spectra'. Saha had the greatest regard for Professor Fowler, and always spoke with warmth and gratefulness of the encouragement and help he had received from him in London. Years afterwards he wrote: 'I took about four months in rewriting this paper, and all the time I had the advantage of Professor Fowler's criticism, and access to his unrivalled stock of knowledge of spectroscopy and astrophysics. Though the main ideas and working of the paper remained unchanged, the substance matter was greatly improved on account of Fowler's kindness in placing at my disposal fresh data, and his offer of criticism, wherever, I went a little astray, out of mere enthusiasm.' This paper and the one 'On the Ionization in the Solar Chromosphere' are by far the most significant and original of Saha's many scientific contributions. Professor H. Dingle once observed: 'On thinking back to the relation which existed between Saha and Fowler, I am tempted to compare it with that between Maxwell and Faraday.'

As one of the interesting and immediate results following from the ionization theory, Saha not only was able to explain the absence in the solar spectrum of the lines of Rb and Cs because of the low ionization potential of these elements, but also to predict that their resonance lines were likely to be observed in the relatively cooler regions of the sun spots. H. N. Russell, following Saha's prediction, looked for and found infra-red pair of Rb-lines, but no Cs-lines, in the Mount Wilson photographs of the spot spectra which, incidentally, had been taken before the publication of Saha's theory.

We may recall at this place that, apart from J. Eggert's paper referred to earlier, a definite suggestion about high temperature ionization, prior to Saha's papers, was also made by the Oxford physicist F. A. Lindemann (later Lord Cherwell) in connection with his controversy with S. Chapman about the origin of magnetic storms (*Philosophical Magazine*, December 1919). He gave the ionization formula for hydrogen in the solar chromosphere. Lindemann, however, did not further develop or generalize the formula ; and above all he failed to notice that the theory of thermal ionization (with accurate values of ionization potentials obtained from spectroscopic data or otherwise) constitutes the key to the interpretation of stellar spectra with their almost bewildering complexity. It was Saha who first recognized this, and worked out the consequences in considerable detail, and he did this independently of Lindemann's suggestion about the high temperature ionization of hydrogen.

In the early twenties R. H. Fowler (in collaboration with C. G. Darwin) developed a very powerful method in statistical mechanics permitting a systematic exposition and working out of the equilibrium properties of matter. He used this to provide a (rigorous) derivation of the ionization formula which as described earlier, Saha had obtained by extending (justifiably) to ionization of atoms the theorem of Van't Hoff, well-known in physical chemistry for its application to molecular dissociation. Also, a significant improvement in the Saha equation introduced by Fowler was to include the effect of the excited states of atoms and ions. Further, it marked an important step forward when in 1924 E. A. Milne and R. H. Fowler in a paper in the *Monthly Notices of the Royal Astronomical Society* showed that the criterion of the maximum intensity of absorption lines (belonging to subordinate series of a natural atom) was much more fruitful in giving information about physical parameters of stellar atmospheres than the criterion employed by Saha which consisted in the *marginal appearance or disappearance of* absorption lines. (The latter criterion requires some knowledge of the relevant pressures in the stellar atmospheres, and Saha, following the generally accepted view at the time, assumed a value of the order of 1 — 0.1 atmosphere). To quote from E. A. Milne[1] : 'Saha had concentrated on the marginal appearances and disappearances of absorption lines in the stellar sequence, assuming an order of magnitude for the pressure in a stellar atmosphere and calculating the temperature where increasing ionization, for example, inhibited further absorption of the line in question owing to the loss of the series electron. As Fowler and I were one day stamping round my rooms in Trinity and discussing this, it suddenly occurred to me that the *maximum* intensity of the Balmer lines of hydrogen, for example, was readily explained by the consideration that at the lower temperatures there were too few excited atoms to give appreciable absorption, whilst at the higher temperatures there are too few neutral atoms left to give any absorption . . . That evening I did a hasty order of magnitude calculation of the effect and found that to agree with a temperature of 10,000° for the star of type AO, where the Balmer lines have their maximum, a pressure of the order of 10^{-4} atmosphere was required. This was very exciting, because standard determinations of pressures in stellar atmospheres from line shifts and line widths had been supposed to indicate a pressure of the order of one atmosphere, or more, and I had begun on other grounds to disbelieve this.'

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[1] E. A. Milne, Obituary notice of R. H. Fowler (1880—1944), *Obituary Notices of the Fellows of the Royal Society*, **5**, 61-78 (1945).

The problem of statistical equilibrium between ionization and electrons subjected to external fields of forces —gravitational and electrical—is of considerable importance. It has been extensively studied by Rosseland, Milne and others. It is found, as is to be expected, that the ionization equation is not influenced by the presence of the field.

In passing it may also be mentioned that the ionization equation is independent of the relative motion between the thermodynamic system and observer. This arises from the circumstance that the temperature, like length, undergoes a Lorentz contraction.

It is hardly necessary to say that in the ionization theory, described above, the electron gas is assumed to be completely non-degenerate. Under conditions of high density and relatively moderate temperatures, the electron gas becomes degenerate, as for example, in the interior of white dwarf stars. Under such conditions, the ionization equation loses its validity. The ionization in degenerate matter is primarily a result of pressure, and not temperature, and the problem has to be treated as an extension of the electron theory of metals. It has been extensively studied in recent years, because, amongst other things, of its interest in connection with atomic explosions.

At this stage, it may not be out of place to refer to the extremely important work by Lee and Yang, Dyson and others, on the theory of what has come to be known as 'hard sphere gas.' For instance, it is found that the energy per particle of a Fermi gas, at absolute zero temperature, requires a correction term which is proportional to the *radius* of the particle. The significant thing is that the correction is proportional to the radius and not to its cube, as one would expect according to the naive picture that the volume available for a particle is the volume of the enclosure *minus* the volume actually occupied by the particle.*

It is of some topical interest to refer to a paper of Saha, 'On a Stratospheric Astrophysical Observatory' which appeared in the *Records of Harvard College Observatory.* In this paper Saha made what at the time (1936) was a very ambitious plea of photographing the solar spectrum at a height of some 50 kilometres, well above the ozone layer ; and he pointed out the enormous gain that would accrue to astrophysics. He also discussed the possibility due to the fact that the ultra-violet radiation from the sun may be several orders of magnitude above that corresponding to a black body at about 6500° K. He wrote : 'This may possibly be due to the fact that the ultra-violet spectrum of the sun may consist of a continuous background of faint light on which are superposed emission lines of H, He, He^+, Fe^+, and other elements which are represented in the visible range by lines of subordinate series, or by patches of ultra-violet continuous light (near about λ 500) leaking through the solar atmosphere from a much hotter region inside the photosphere, as suggested by Professor H. N. Russell.'

Saha's work provides many examples of projecting 'new ideas' from physics into astrophysics. These were often remarkably bold, and in some cases even highly speculative. Witness, for instance, his early work on the theory of selective radiation pressure. As another illustration, we may cite his work on solar corona. In the case of the corona an outstanding problem is that of the mechanism or source responsible for the high degree ionization—loss of 9 to 13 electrons—of the iron atoms, and also nickel in the inner corona, as conclusively demonstrated by B. Edlen's remarkable work (1938) on the origin of the coronal bright spectral lines. D. Kundu working under Saha showed that some of the lines may be due to highly ionized cobalt atoms. The intense ionization, as also the excessive broadening of the Fraunhofer lines in the scattered radiation from the outer corona, and the strong coronal radio-emission in the region of wavelengths of the order of a few metres, all suggest coronal temperatures of the order of millions of degrees, but the origin of these temperatures which

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*The null-point energy per particle is

$$E = \frac{3}{5}\frac{\hbar^2 k_0^2}{2m} + \frac{\hbar^2 k_0^2}{2m}\frac{2k_0 a}{\pi}$$

where a is the particle radius and k_0 is the maximum Fermi momentum, that is

$$k_0 = \left(\frac{6\pi^2 n}{g}\right)^{\frac{1}{3}}$$

where n is the number of particles per unit volume and g is the weight factor. (K. Huang and C. N. Yang, *Physical Review*, 1957).

are comparable to those occurring in stellar interiors is largely still an unresolved problem. Saha found it difficult to accept the existence of such high temperatures. In fact, to account for the Edlen lines he advances in a number of papers the somewhat quaint hypothesis that the highly charged ions necessary for the emission are produced as a result of some form of nuclear fission occurring in the sun's outer atmosphere—he suggests tri- or quadri-fission of U or Th. The problem of the emission of radio waves from the sun and other stellar bodies also engaged his attention, and he discussed the like role of the magnetic field and the hyperfine—structure level—splitting of the ground state of the H-atom (*Nature*, **158**, 1946). He failed to recognise, at any rate explicitly, the possibility of the occurrence as line emission of the 21-cm hydrogen line in radio spectra. (He was not aware at the time of the earlier prediction (1944) of H. C. van de Hulst.)

In conclusion—and this has been a very sketchy account—may I quote from one of the most distinguished astronomers of our time, Otto Struve : 'His (that is, Saha's) brilliant work on the ionization of stellar atmospheres, more than thirty years ago, resulted in a revolution in scientific thought comparable to that which occurred when Fraunhofer and Kirchhoff laid the foundations of the spectroscopic investigations of the celestial bodies. Saha's work has been a source of constant inspiration to virtually every astrophysicist during the present generation. My own early studies in stellar spectroscopy received an impetus from his work, and I believe that I have never written a scientific article in which I have not in one form or another made use of his theory of ionization.'

AN EXPERIMENT IN SPACE BIOLOGY

N. SUTARIA

Sponsor, Science Club, Shree Vidyanagar High School,
Usmanpura, Ahmedabad

Much progress has been made in space travel since the Russians launched the first man-made Sputnik on October 4, 1957. Several astronauts both in the U.S.A. and Russia have orbited several times round the earth in their space ships. On these journeys, the spacemen took their own prepared food. Plans are also being made to send a man to the moon. But in this case, the journey will be longer and scientists will have to think of providing food for the astronaut and also think of devices to eliminate the waste products. To understand some of the problems, an experimental project was planned to keep a mouse in a closed system where the food to the animal was in the form of an alga grown in the system, and its waste products were disposed of in a useful way.

This article describes the details of the experimental project undertaken by the science club in keeping alive a mouse for six days in a closed system. Of course, this project does not take into account the absence of gravitational force, but a study was made to see how far algae could be used to supply air and food to this animal kept closed in a cabin.

Two problems had to be faced. One was how to regenerate the atmosphere in a closed system and the second, how to convert the urine and excreta of the animal into non-toxic gases and water-soluble nutrients which could be used again. The first problem was tackled by growing *Chlorella*—an unicellular alga—both as food for the animal and as an agent to purify the atmosphere in the cabin of the animal. The second problem was tackled by utilizing bacteria to first break down the waste products before using them as nutrients in the algal culture. The bacteria for this were obtained from sewage.

Methods of Study

A batch of six active members were selected and three of them were assigned field work and the other three were given experimental work. After several trials *Chlorella* was cultured in soil solution. The latter was prepared by autoclaving garden soil, well stirred in water. After cooling, the filtered solution was used. This filtrate was used in quantities of 50 cc, 100 cc, 150 cc and so on up to 500 cc, diluted to 2000 cc of glass distilled water. By trials it was found that 500 cc of soil solution diluted to 2000 cc was the best for the cultures of the alga.

The animal selected was trained for eighteen days to depend entirely on a diet consisting only of the alga. It was observed that the addition of a little table salt to the alga made it more palatable to the animal.

Many designs of the apparatus were tried and finally one was found to work well. This design is shown in Fig. I.

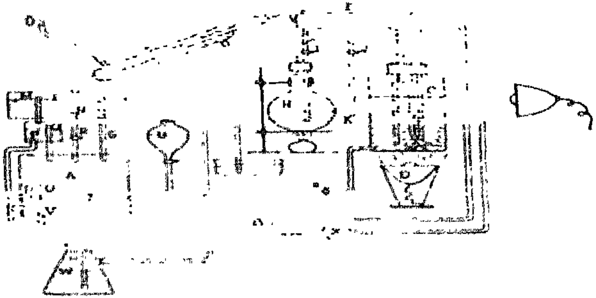


Fig. 1. Diagrammatic sketch of the apparatus set up.

The animal was kept in a chamber of one cubic foot capacity fitted with a sieve-like floor. This enabled the urine and excreta to collect below (V), which acted as the septic tank. The foul air given off by the animal in chamber A was expelled by the air pump B into the algal culture tank C. The tank was illuminated by an electric light. The alga in the tank carried on photosynthesis and in this process built up carbohydrates and released oxygen. The oxygen was led through to the condenser and then to the water tank. From here it was led to the living chamber through tube G. The air cycle was thus completed. The water from the algal tank was taken into a boiling flask H through the regulatating stopper I. The tube with cock I worked as a siphon and hence flask H had to be kept at a level lower than that of the algal tank. The tube J-K with cock J was used as a starter to suck water to fill the siphon. When the siphon was filled, cock J remained closed, and when water in the flask H was exhausted, it was refilled by opening cock I. The steam from flask H was passed through the condenser. The condensed water collected in the water tank F. This could fill up only to the level of tube M. Any excess of water overflowed into the smaller tank below. From here this water overflowed into the chamber through O. One end

Q of the tube PQ had a narrow opening through which water trickled. This trickle was used by the animal for drinking, whenever it needed it. The stop-cock R of the tube N remained usually closed, but it could be opened to empty tank F, or to wash the living chamber which was done once every 24 hours. Food was supplied four times a day to the animal. This was done by opening cock S and allowing water with algae to flow into a food-dish T in the living chamber.

The container U had some salt solution and this was allowed to flow in drops on the algae in the food dish. The salt was added to make the food palatable.

As explained earlier, the floor of the chamber was a wire-mesh which allowed all liquids and excreta to go into the lower part of the chamber. The waste products with water were taken through a tube to the septic tank W which had the necessary bacteria to break down the waste matter. The final end products were taken up to the algal tank by the water pump X. Any bacteria taken with the water would be destroyed by the ultra-violet rays of the lamp below the algal tank.

Water tank F and living chamber A were of wood, made water-proof and air-tight by coating all sides with three coats of wax.

The previously trained rat was kept alive in the closed system for six days and the joy of the club members was boundless when it was removed alive at the end of the period.

The foregoing account is reproduced here as an example of what an energetic and enthusiastic sponsor of a science club can initiate as a working project. The correctness of the working of the closed system and the scientific principles involved and explained are the responsibility of both the sponsor and the club members.

Editor

AROUND THE RESEARCH LABORATORIES IN INDIA

During World War II, the Government felt the need to mobilize the country's scientific resources for the war effort. In order to do this, the Council of Scientific and Industrial Research (CSIR) was constituted in 1942 to promote, guide and coordinate scientific and industrial research for the economic development of the country. With the advent of independence in 1947, the National Government under the far-sighted leadership of Shri Jawaharlal Nehru, began to plan the industrial and technological development of the country. This is possible only if we ensure a parallel development of scientific and industrial research by our own scientists in our own laboratories.

The pioneering efforts of the late Dr. S. S. Bhatnagar, F.R.S., have resulted in the establishment of a chain of 27 National Laboratories—an index of expansion of science from independence to date. These 27 laboratories are located all over the country from Karaikudi in the south to Jammu in the north, and from Bhavnagar in the west to Jorhat (Assam) in the east. All these institutions are carrying out very important scientific work. The work which they do does not come under the purview of Universities or Industry. Their main emphasis is on basic problems of science. This effort to enrich knowledge is in the best interests of industry, as the science of today is the technology of tomorrow.

Besides these national laboratories, there are several other laboratories, much older and well established which are also doing very good work and have gained a name for themselves.

It is proposed to publish feature articles of the activities and achievements of a few of these laboratories. We begin the series in this issue with an account of the National Physical Laboratory, New Delhi.

—Editor

NATIONAL PHYSICAL LABORATORY

The National Physical Laboratory was the first among the chain of laboratories to be set up by the Council of Scientific and Industrial Research. The laboratory was opened at its present site by the late Sardar Vallabhbhai Patel in January, 1950. The laboratory owes its stature to the pioneering efforts of its first Director, the late Dr. K. S. Krishnan, F.R.S., an eminent physicist of international repute. Over a period of 14 years he built up a high tradition of research work.

The laboratory conducts basic and applied research in various branches of physics. Industries are helped by the development of new processes, utilizing mostly local materials. The laboratory has been entrusted with the setting up of standards of mass, length and time and other derived standards.

The laboratory has about ten divisions and five sections or units in which the scientific work is carried out.

Standardization

The enactment of the Weights and Measures Act in 1956 was an important step in the progress of the country. The National Physical Laboratory is the Custodian of the National Physical Prototype of the kilogramme and the metre which were acquired from France. The sets of cast iron weights of different masses made by the laboratory proved very helpful in popularising the metric weights. These standard weights and sets of standard capacity measures were supplied to the states. Successful steps were taken to improve the quality of balances manufactured in India and high quality balances are now available, in the country.

The Standard Metre Bar acquired by the institute is made of platinum iridium alloy. The laboratory also possesses apparatus for precision measurement of length required in engineering and trade.

The third main standard is that of time. Scientists, and technologists particularly, astronomers, telecommunication engineers and surveyors require precision in time measurement. The quartz clock in the NPL measures time to such an accuracy that after three years of continuous working the possible error is a fraction of a second. Such a quartz clock is the core of the *Standard Time and Frequency Broadcasting Station of NPL*, located in Kalkaji. It is the twelfth international station of its kind, the two nearest to India being Tokyo (Japan) and Turin (Italy). The Standard Time Service is broadcast under the sign ATA on the 30 metre band every 15 minutes from Monday to Friday between 11.00 and 13.00 hours IST. The accuracy of the time broadcast is within five-hundredth of a second. A monitoring centre at the NPL compares the time signal with those from Moscow, Greenwich, Washington and Tokyo.

The quartz clock has as its main part a cut crystal of quartz (a common mineral found in beach sands), which has the property of oscillating at a constant frequency when excited electrically. This phenomenon is known as Piezo-electric effect. These regular vibrations in quartz, thus generated, are utilized for measuring time. The quartz crystal at Kalkaji vibrates at the rate of 100,000 times per second.

To meet the requirements of more precise timings for satellites and spaceships, arrangements are being made to set up an 'Atomic Clock'.

Besides the three basic standards of mass, length and time, standards in other fields like electricity, thermometry and photometry are also being maintained.

Research

Research of both academic and applied nature is being carried on. The laboratory is well-equipped with modern apparatus for research in various fields of physics. Some of these are (1) the Collins Liquid Helium Plant and a large electromagnet for research at low temperatures, (2) the double beam infra-red spectrometer, (3) R.C.A. electron microscope capable of a magnification of 40,000, (4) Edward's Finch Type electron diffraction apparatus, and (5) Philip's X-ray diffraction unit and Weissenberg camera.

Low Temperature Physics

The physical properties of solids at low temperatures, for example, thermal conductivity, electrical conductivity and magnetic susceptibility are studied in this section. They are helpful in formulating a complete theory of the solid state. Such properties are being studied at very low temperatures, 4°K to 10°K, which are being produced on account of the availability of liquid helium.

Solid State Physics

A new method for the determination of thermionic constants of metals developed by the late Dr. K. S. Krishnan is being extensively applied in the study of metals, alloys, crystals and semiconductors. Optical crystals and electrical properties of ionic crystals like alkali halides, both pure and doped with impurities, are being studied.

Acoustics

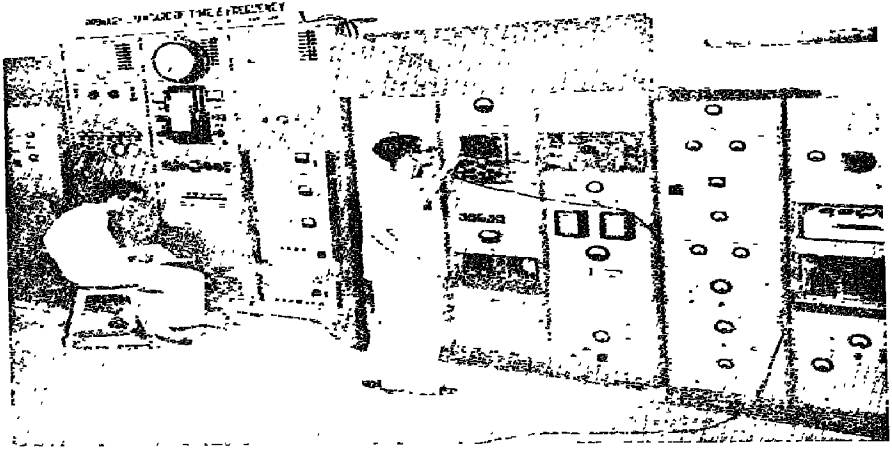
Extensive researches on the amount of heat produced by the passage of sound energy through a liquid established the law of equivalence as Joule's Mechanical Equivalent of Heat, $J = 4.18 \times 10^7$ ergs. Researches on the alternation of sound waves in a medium have established the equivalence of sound energy and heat energy. The effect of ultrasonic irradiation on chemical reactions has been investigated.

Optics

The main lines of research here are spectroscopy applied to detection of metals in blood and tissues. Manganese poisoning among the workers in manganese mines is a serious type of illness which may lead to mental imbalance. It is very necessary to estimate the manganese content in blood for diagnosis of this malady. From the spectra of studies made, it is concluded that the highest concentration of manganese in the blood of the patient is 400 μmg per 100 cc, the normal content being 13 μmg per 100 cc. Research on the application of spectroscopy to combustion problems is being pursued. For a study of combustion in flames, a special form of glass apparatus has been constructed. Here atomic oxygen is produced, which, combining with acetylene, gives a fine stable flow in vacuum.

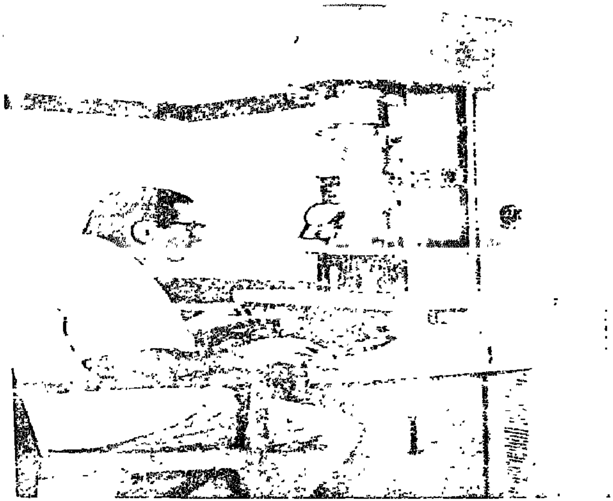
Other lines of investigation in this division are interferometry, image formation, and aberrations in optical instruments, vision and colour perception by the human eye at low levels of illumination.

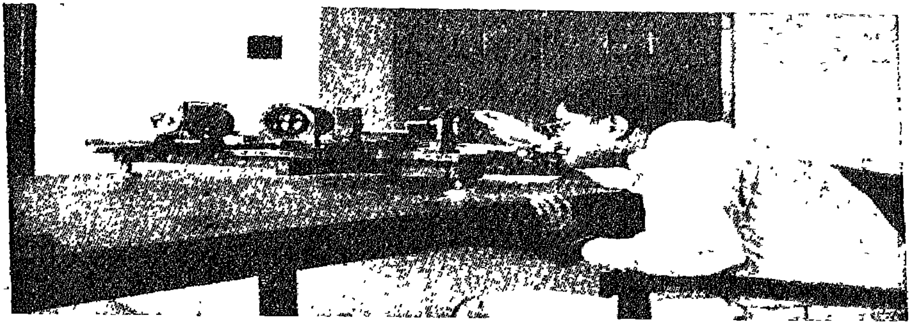
National Physical Laboratory Building



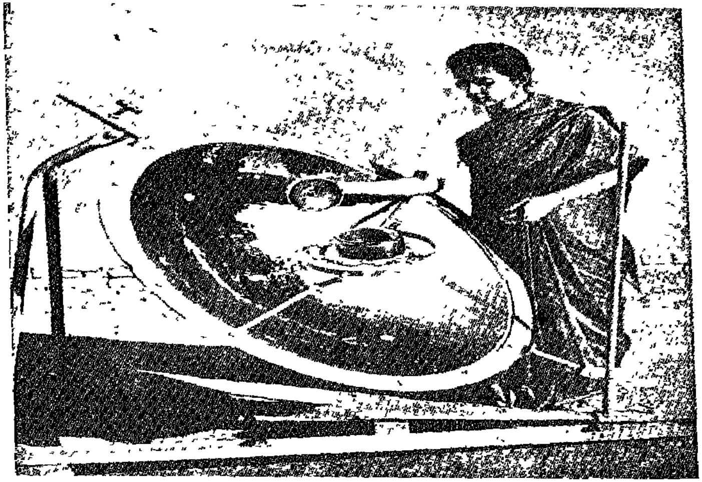
Scientist engaged in broadcasting standard frequency signals from NPL

Liquid helium plant





Twyman—Green interferometer being used for testing prisms



Solar cooker in use

The laboratory is rendering help to industries. In this division two examples could be cited : one is the technical advice rendered to Indian manufactures of railway signal glasses, as a result of which the quality of the products has vastly improved. Opinion was asked from the laboratory about the quality of microscopes supplied by foreign countries. Tests were conducted utilizing interferometers designed and fabricated in NPL. The report proved extremely useful to the Government in coming to a decision regarding the programme of manufacture of microscopes in India.

Electronics : Great deal of work has been done in the fabrication of microwave tubes, magnetrons and klystrons. Techniques developed are being applied to the study of propagation of electrons in the magnetic fields. Using vacuum tubes, many new circuits were evolved for obtaining sequential switching which has found application in automatic timing road colour signals in Delhi.

Electron Microscope : Some years ago NPL was one of the four institutes that could boast of an electron microscope. Using electron beam, this microscope can magnify 40,000 times. Studies are made of the structure of metallic films and crystals with the aid of the electron microscope. This instrument is also used by guest workers from universities and other institutions in the study of bacteria, ultrastructures of plant cells and plant structures like cilia, sculpture of diatom walls, etc.

Radio Propagation and Space Research

The Radio Propagation Unit is actively pursuing (*i*) measurement of ionospheric absorption using cosmic radio noise, (*ii*) study of ionospheric irregularities from scintillation of radio stars, (*iii*) propagation of low frequency radio waves, (*iv*) physics of the upper atmosphere, (*v*) interpretation of the data obtained from C_4 ionospheric recorder, (*vi*) true height computations, (*vii*) solar radio astronomy using interferometers, and (*viii*) radio patrol of solar flares.

Since the launching of artificial satellites and space ships, arrangements have been made for the reception of the radio signals transmitted from them. And from the analysis of the intensity of the signals received, the total ionization content from ground to the satellite height has been derived.

Rain and Cloud Physics

Studies in this unit are undertaken on cloud formation both in the laboratory and under natural conditions. A beginning has been made in promoting artificial rain by seeding from an aeroplane. A 3.2 cm radar has been in use during monsoon seasons and interesting results have been obtained.

Mathematical Research

The theoretical group on quantum physics and mathematics is actively pursuing research on various topics.

Applied Research

Help is rendered to industries by giving technical advice which in many cases results in considerable improvement of their products. Two examples have already been cited about the railway signal glasses and the testing of microscope objectives. Tests on materials used by industry are undertaken and the problems referred to by them are also investigated. Such testing covers a wide field among which may be mentioned weights and measures, optical instruments, electrical appliances, various engineering materials for hardness, fatigue, impact and strain, and several other industrial materials like bicycle components, radio components, lead pencils, cinema carbons, etc.

Manufacturing processes for carbon products and ceramic capacitors have been developed. A process has been worked out at the NPL for utilizing titanium dioxide to produce ceramic capacitors. Capacitors are used in radio receivers, fluorescent lamps, amplifiers, hearing aids and measuring instruments. The production cost, as worked out on the basis of pilot plant runs of 1,500 units per day, comes to 13 nP. per capacitor of 100 pF (pico-farad, a unit capacitance). A new type of thermal capacitor has also been developed. These are known as thermocapacitors. These are as sensitive as a thermometer to temperature changes but with the difference that they can communicate, by remote control, the recorded temperature through radio waves. A transmitter fitted with thermocaps can be used as a self-operating fire alarm. The potentialities of thermocapacitors are immense. They can be used in weather balloons. They act like a talkie thermometer and spell out temperatures as the balloon ascends.

Facilities for Training

In the vacations, university teachers are invited to avail of the laboratory facilities. Similarly nominees of other industries are invited to work in the branches of their special interest.

Library and INSDOC

At present the total number of books, periodicals and other scientific publications held in the library exceeds 1,00 000. It receives about 1,500 journals. This represents a good collection of scientific publications in the field of mathematical and physical sciences. The resources of the library are supplemented by INSDOC (Indian National Scientific Documentation Centre). This Centre provides documentation services to scientists, technologists, industrial organizations, research institutions, universities, etc. It receives and retains all scientific periodicals which may be of use to the country, and it acts as a channel through which the scientific work of the nation is made known and available to the rest of the world.

INSDOC has been publishing a semi-monthly *INSDOC List of Current Scientific Literature*, a monthly *Bibliography of Scientific Publications of South and South East Asia*, and a quarterly periodical on documentation, called *Annals of Library Science*.

Science Museum

A museum has been organized to exhibit models of educative value to show the development of physical sciences. A programme of guide lecturing through the museum galleries has been set for school and college groups. Schools can take advantage of this museum and take the students in batches to the NPL, the museum and the planetarium there.

Planetarium

This is housed in a special building with a 18 ft. diameter dome. The planetarium was presented by the German Democratic Republic. A total of 5,000 stars and a few nebulae can be seen. Fluorescent exhibits of astronomical interest are also exhibited. With a 3 in. refractor telescope, the whole unit is acting as a centre for promoting popular interest in astronomy.

CLASSROOM EXPERIMENTS

A METHOD OF CULTURING FERN GAMETOPHYTES

Many schools and even some colleges which teach the life-history of ferns, often do not have specimens of the prothallia to be shown to the students. They give specimens of the sporophytes for examination and drawing of sketches, but when it comes to the gametophytes, they either have a single whole-mount obtained from a biological supply firm, or in its absence, they show pictures of it on a chart or a book. To help teachers over this difficulty, a simple method of culturing fern gametophytes is described here

Fern gametophytes may be found wherever fern sporophytes are common This is so in climates where they grow easily. But in places with a hot and dry weather, gametophytes are often difficult to find. Often the specimens collected are not satisfactory.

Method of Culturing

Select a few fern leaves with mature spores and put them in a cardboard box and allow them to dry for a few days. Cover the box to prevent dust from entering.

Take a small flowerpot (3"—4" high) and fill it with dry moss, pieces of paper and tissue paper. Moisten this stuffing. Invert the flower pot over a flat mud pot, as shown in Figure 1. Fill the flat pot up to a depth of 1"—1½" with water. Place both of them on a sheet of glass. Cover this flower-pot and the lower flat pot with a wide-mouthed fruit jar or a battery jar.

Now, shake the dried fern leaves in the box over a piece of paper or on the bottom of the box itself. The spores will be freed, and they can be collected as a fine brown powder. With a clean pipette or ink-filler suck up the dry powder, raise the covering jar and spray the dry spores on the moist surface of the inverted flower pot. With a little experience the spores can be sprayed evenly. Put back the cover and keep the whole set-up in a cool shaded portion of the garden or the window. The spores begin to germinate in a few days and the prothallia mature in about 8-10 weeks. Add some water to the flat pot from time to time to replace that which may be lost by evaporation. If possible, instead of water a half dilute Knop's solution may be added.[1] Sporophytes begin to appear in about

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[1] $Ca(NO_3)_2$, 1 g. KCl, 0,25 g. $MgSo_4$, 0.25 g. KH_2PO_4, 0.25 g. Trace of ferric chloride. Distilled water, 1 litre.

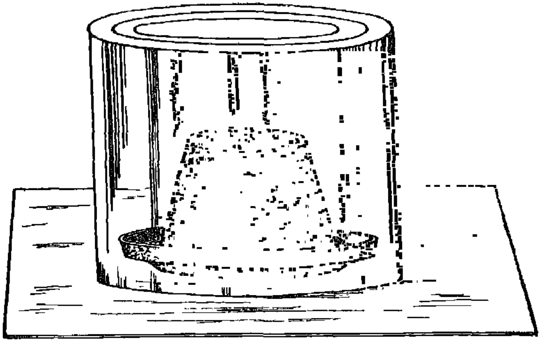

Fig. 1. Fern spore culture.

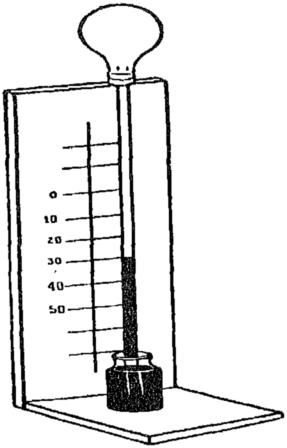

Fig. 2. Air Thermometer.

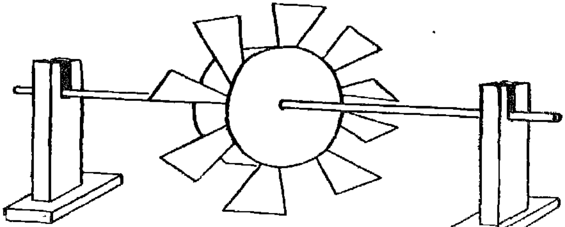

Fig. 3. Experiment to demonstrate energy produced.

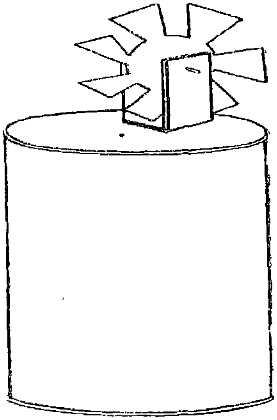

Fig. 4. Model of a steam turbine.

8 weeks. The gametophytes may be examined from time to time and a few of them may be preserved in F. A. A.[1] or formalin for use later on for microscopic examination.

To observe sperms, remove the glass cover from the culture and allow the gametophytes to wilt but not dry out. Mount one or two such wilted gametophytes on a slide in a drop of water. The sperms will come out of the autheridia in about 2 or 3 minutes.

Start 3 or 4 culture pots at the same time, so that even if one or two of them fail, you can be sure of a supply of gametophytes.

S. DORAISWAMI

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[1] Formula : Alcohol 70%, 85 ml., formalin commercial, 10 ml., glacial acetic acid, 5 ml.

AIR THERMOMETER

Temperature is the degree of hotness of a body. The expansion of a substance enables us to measure temperature ; for example, the hotter the material in a thermometer, the more it expands. Common thermometers are filled with mercury or with coloured alcohol. Both these substances remain as liquid through a wide range of common temperatures, and so are appropriate for domestic purposes. The first thermometers used air as the expanding substance.

To make an air thermometer, fit a flask made from an used electric bulb fitted with a one holed stopper with a 60 cm. glass tubing in it. The stopper must be sealed air-tight by dropping molten wax from a candle. Paste a strip of paper for a scale behind the tube. Place the lower end of the tube in a bottle of cold coloured water. Warm the bulb gently to drive out some air so that when the bulb cools to room temperature the coloured water may rise to about half way in the tube (Fig. 2).

To graduate the scale, let the thermometer stand in a room for several hours. Have another thermometer near the bulb. Make a line on the paper at the level of the water and mark the reading of the thermometer at this point. Next move your thermometer to a warm place to stand for an hour with the other thermometer near the bulb. Mark the water level and the temperature. Move again to a cool place and again mark the level and temperature. Divide the space between these marks into equal divisions and mark off the corresponding temperature.

From *Handbook of Activities—classes* VI—VIII accompanying the *General Science Syllabus*, NCERT, 1963 (under print).

ENERGY OF A FALLING BODY

Kinetic energy has many forms and one example is the energy of a falling body. This can be demonstrated with the following device.

Cut slots down the sides perpendicular to the ends of a cotton reel or a wide disc of cork. Insert pieces of tin or wood as shown in the figure. Use a knitting needle or a thin pencil as an axle. Support the axle on a pair of grooved wooden stands. Direct a stream of water from a tap or from a tank to see the vanes (tin pieces) moving by the kinetic energy of the water. Relate this with the idea of utilizing water power from dams and rivers (Fig. 3).

[*Ibid.* Grade VI. Activity for concept 3a, Energy under the Unit, Energy and Work of the *General Science Syllabus*].

MODEL OF STEAM TURBINE

To make a model of a steam turbine, first cut radial slots from a circular piece of tin sheet and twist the blades to remain perpendicular to the plane of the tin sheet. Punch a hole in the centre and pass a knitting needle as axle. Bend another piece of tin into a U-piece with two holes and solder it on the lid of a kilo-size tin. Make a fine hole near the base of the U-piece. Insert the axle through the holes for support as shown in the figure (Fig. 4).

Fill the can with about a fourth part with water and close the lid tightly. Heat the water to boiling till steam escapes through this hole and moves the blades.

[*Ibid.* Grade VIII. Activity under concept 2a, b. under Unit Energy and Work (Engines).

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SCIENCE ABROAD

THE BIOLOGICAL SCIENCES CURRICULUM STUDY (BSCS)

GLEN E PETERSON

Professor of Biology, University of Houston, Houston, Texas, U. S. A., and Writer and Consultant, BSCS, University of Colorado, Boulder, Colorado, U. S. A.

During the past summer (1963) India's Unversity Grants Commission, the National Council of Educational Research and Training and the United States Agency for International Development through its Teachers College of Columbia University team cooperated to sponsor an exciting Summer Institute for Biology Teachers at the University of Madras. This experimental institute was designed to acquaint the participating secondary school teachers with the newer concepts of biology and effective ways for their teaching. Participating teachers representing every state in India from Assam to Bombay, and Cape Comorin to the Punjab, were in attendance. The institute was directed by Dr. S. Krishnaswamy, Reader in Zoology, at the University of Madras. The entire biology staff at the university plus a number of distinguished visitors from various places in India cooperated in this presentation of the most up-to-date biology. It is hoped that the participating teachers will return to their schools and pass this new knowledge on to their students. I was fortunate enough to be selected as the American Specialist from the United States Department of State for these sessions.

The sessions of the Summer Institute in Madras were supplemented by field trips, film shows, research talks, etc. However, the lectures and practical work were centered on *High School Biology* as developed in America by the BSCS. Interest in these materials was keen, and it is the purpose of this article to outline the story of their development and usage.

The BSCS was organized in 1959 by the Education Committee of the American Institute of Biological Sciences (AIBS). The AIBS is an organization of over 85,000 biologists from nearly all the research and teaching fields of biology. Stated simply, the mandate to the BSCS was to seek the improvement of biology education. This was of great concern in America as it was quite apparent that many outdated ideas of science in general and biology in particular, were being taught in the schools.

Since most (about 85%) of the secondary school students in America take biology as a science, it was decided that the first efforts of the BSCS should concentrate on High School Biology.

The BSCS established and still maintains offices at the University of Colorado, Boulder, Colorado, U. S. A. It selected as its President, Dr. Bentley Glass of Johns Hopkins University, and as its Director, Dr. Arnold Grobman of the University of Florida. Its major source of financial support (to date, equivalent to about rupees three crores) has been the National Science Foundation. General policy for the BSCS is established by a 27-member Steering Committee which includes research biologists, high school biology teachers, science supervisors, education specialists, medical and agricultural educators, and school administrators.

Instead of preparing one set of biology materials for use in high school biology, the BSCS, for reasons which will soon become evident, prepared three parallel sets of books. These are known as the Blue, Yellow, and Green Versions of BSCS *High School Biology*. Each is complete with text materials, laboratory practical work for the student, and Teacher's Guides. These materials were prepared by teams of biologists (both university staff members and high school teachers), working at Summer Writing Conferences during three successive summers—1960, 1961, and 1962. The work of the second two summers representing revisions of the original materials was based on a wide programme of testing and professional reviewing.

The primary purpose of each version of *Biology* was to prepare a course suitable for wide use in the *average* high school with *average* 10th grade students (American high schools run through the 12th grade after which qualified students may elect to matriculate in a college or university). This course should give the student a basic understanding of science in general as well as biology in particular. And such a course should build a scientific literacy in the student which would prepare him for responsible citizenship in an increasingly scientific and technological world. The BSCS seeks to teach science as a way of *thinking* through to answers. To do this, the underlying concepts and understandings of biology are constantly stressed both in lecture sessions and laboratory practical work. The student actively participates in both lecture discussions and practical period exercises. By so doing the student gains an insight to the scientific process, *per se*, rather than just remembering a mass of unrelated, specialized biological terms.

Specifically, the BSCS can be said to differ from the conventional treatments of biology in at least three major aspects.

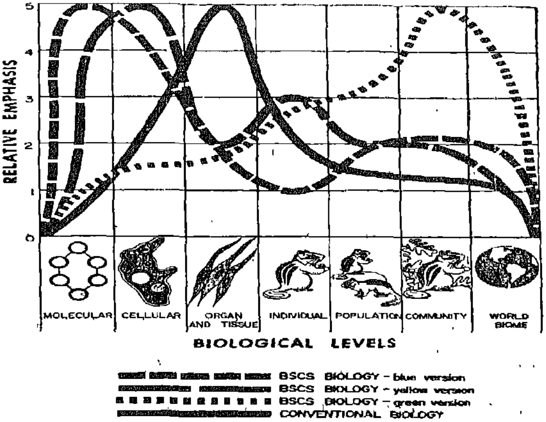
First, even with three different versions, all BSCS materials have significant unifying threads. This unity arises from the agreement of the writers that nine basic emphases should be woven in and through each of the versions. These are :

1. Change of living things through time—in a word, *evolution*
2. Diversity of type and unity of pattern of living things
3. Genetic continuity of life
4. Complementarity of structure and function
5. Biological roots of behaviour
6. Complementarity of organisms and environment
7. Regulation and homeostasis : the maintenance of life in the face of change
8. Science as inquiry
9. Intellectual history of biological concepts

Secondly, the BSCS is a general high school programme that has resulted from a free cooperation between *teams* of research biologists, high school biology teachers, and other contributing specialists. This cooperation has yielded a completely new start in high school biology based on the most up-to-date knowledge of the field. For example, where traditional texts emphasize the organ and tissue level in biology, BSCS biology versions place greater emphases on other levels of biological organization.

Thirdly, BSCS biology puts a greater stress on active laboratory work by the students than do traditional biology courses. American teachers using BSCS materials reported spending more than double the class time in the laboratory than they had with traditional materials. Furthermore, the traditional illustrative type of laboratory exercise is de-emphasized and stress is given to investigative exercises which introduce the student to the inquiring processes of science.

The figure on the next page demonstrates how each of the BSCS versions emphasises different levels of biological organization. How can one justify three different approaches to modern biology ? Let us look at the reasons for the decision to produce three approaches rather than one version of up-to-date biology.



Although biology can be thought of in terms of a single field of knowledge, at the present time there are a variety of views as to how the component parts of the subject are interrelated. Thus biology differs somewhat from mathematics and the sciences of physics and chemistry. The latter subjects, to much greater extent than has biology, have utilized single-track approaches to the development of their present states of knowledge. But just as variation is characteristic of the biological world, so is variation to the study of biology a characteristic of biologists. For example, some biologists (be they research people, or teachers, or both) think of molecular biology as the fundamental approach to biology. Others begin with the cell as the elemental, independent, structural and functional unit in biology, still other biologists consider the ecological and behavioural patterns of individual and groups of organisms to be of first importance in the understanding of biology. Naturally no one of these approaches can be separated completely from the other two. But each does represent a separate field of emphasis for the study of biology. Thus, these three, of the many possible approaches to biology, represent the basic approaches of the Blue, Yellow, and Green Versions, respectively.

There is, as yet, no indication that any one version is more suited to a rural or urban setting, to a more or less sophisticated student body, or to a more or less well-prepared teacher. The choice of versions seems best to be made by the teacher based on the background and interests of himself and his students.

In addition to the materials issued with each version (texts, laboratory manuals, and teacher's guides), the BSCS has developed many supplementary materials for use with its biology courses.

There is, for example, a series of six-week laboratory block units available. Any one of these blocks may be used to supplement any of the versions of BSCS biology.

Each block is centered around one area of biology and through a continuous six weeks of laboratory work in this area, it is hoped that a student will gain an insight into the depth of scientific inquiry.

The BSCS has through the facilities of the Educational Testing Service in Princeton, New Jersey, U. S. A., and the Psychological Corporation of New York City, U. S. A., constantly examined its experimental classes. The results of these testing programmes have given valuable information to guide in the revision of BSCS materials.

Other supplemental materials for the BSCS include the BSCS Pamphlet Series, with eight pamphlets issued each year on current, specialized topics in biology, and two volumes of *Biological Investigations for Secondary School Students*. The latter is a series of research prospectuses which may be used by the individual student as an out-of-class, long-range research activity.

There is also a series of nine BSCS technique films to illustrate various modern and frequently used laboratory techniques. A series of 'Single Concept' films is in preparation, to be used in connection with BSCS biology. This series will include short films to illustrate specific concepts found in BSCS biology.

To date BSCS materials have been prepared and tested with the aid of more than 100 writers, 100 teachers, and 160,000 students. All versions have been used successfully in large and small schools, in rural and urban areas, in every section of the United States, in public schools and private schools.

As a result of this extensive programme, the second revision of the BSCS biology texts is now being published by commercial publishers and will be available to anyone from the following American firms :

Blue Version—Houghton-Mifflin Company
Green Version—Rand, McNally Company
Yellow Version—Harcourt, Brace & World Company
Laboratory Blocks—D. C. Heath and Company

Teacher's Handbook—John Wiley & Sons, Inc.

Biological Investigations for Secondary School Students. Research Problems in Biology for the Schools—Doubleday & Company.

All other BSCS materials and information—BSCS office, University of Colorado, Boulder, Colorado, U.S.A.

The royalties from the sale of these books will be placed in a special fund to pay for future revisions, as needed, of BSCS materials.

A major concern of the BSCS has been the training of teachers to use properly this newer knowledge in biology. Along with mathematics and the other sciences, hundreds of teacher-training programmes in modern science are being conducted in colleges and universities throughout the United States. During the biology sessions, the BSCS materials are being used in much the same manner as they were during the past Summer Institute in Biology at the University of Madras. The BSCS has issued a special publication, *Guidelines for Training Teachers*, for the use of directors of these institutes.

Interest in the BSCS programme has been expressed by many countries. Hence the BSCS has established an International Cooperation Programme. The following is a resume of some active work along these lines from various parts of the world.

Brazil	A preliminary set of laboratory exercises of BSCS biology, Green Version, Brazilian adaptation, in Portuguese was issued in the spring of 1962. Further work is continuing on other BSCS materials being adapted for Brazil.
Columbia	Work is in progress on a Latin American edition of BSCS biology Green Version, in Spanish, with financial assistance from the Ford Foundation. Preliminary testing has been done and the final edition of the materials will go to press shortly.
Europe	At the QECD meeting in Switzerland, high school biology teaching, with specific reference to the BSCS, was discussed. BSCS representatives included Dr. Hiden T. Cox, Chairman, BSCS International Cooperation Programme ; Dr. Herman Muller, BSCS Steering Committe member, and Mr. Phillip Jordyce, a BSCS experimental teacher. Several committees in England are currently considering problems of improving high school teaching. BSCS Chairman, Dr. Bentley Glass, met a number of persons in England during

the summer of 1962 to discuss BSCS programmes. He also spoke on the BSCS for a British Broadcasting Corporation programme. Dr. Elizabeth Perrott, University of Keele, visited BSCS headquarters as well as some BSCS writing teams and BSCS classes during her visit to the United States, as background for her work on a committee of high school biology sponsored by the National Conservatory. Dr. H. V. Wyatt, Bradford Institute of Technology, also visited BSCS offices. And recently Mr. Peter Kelly, Bexley Grammar School, Welling, Kent, has excellently reviewed the BSCS in the *School Science Review* (March, 1963). Mr. Kelly gathered information for his article during a visit to the U.S.A., and has taken special care to view BSCS methods in the light of teaching situations in England.

Japan A committee of Japanese biologists concerned with science education is now in its organizational stages : Dr. Bentley Glass, BSCS Chairman, has been invited to work with this group. In addition, a group of Tokyo high school biology teachers is studying the BSCS Blue Version. Dr. Arnold Grobman, BSCS Director, met this group in September, 1962.

Republic of the Philippines With financing from the Philippine National Science Development Board, a writing team has been set up on the University of the Philippines campus in Quezon City to prepare an adaptation of the Green Version of BSCS *High School Biology* for local use. Writing team members were drawn from the ranks of high school teachers, university biologists, and the University College of Education. Dr. Victor Larsen, a BSCS writer, is acting as a U.S. observer with this group. The efforts of this group were planned for experimental use in the school year starting July, 1963. Dr. Licera Louisano, Dr. L. Sangolong, and Dr. Dolores Hernandez from the Philippines have visited BSCS headquarters in the U.S.A. in preparation for their efforts.

Thailand Each month since July 1962, *Science*, the publication of the Royal Science Society of Thailand, has carried a section of the Thai adaptation of BSCS biology, Yellow Version laboratory manual. These articles were prepared by Dr. Panee Chowanich and Professor Rojanne Jaiuprakora. These materials are being used by experimental teachers who then report their experiences back to the writers.

Thus, it can be seen that a varied approach to the adaptation of BSCS materials has been taken in different parts of the world. What can a particular country expect from a programme in modern biology for its secondary schools ? I believe, to answer this question, I shall quote from Dr. Bentley Glass writing in *The School Review* (Spring, 1962) :

"*In sum and substance, what is the BSCS programme that past efforts* to improve the science curriculum of the secondary schools were not ? One might say two principal things in reply. For the first time in the history of American education we now see a large number of research scientists, from the colleges and universities, taking part in a cooperative effort with high school teachers of science and science supervisors to replace an antiquated body of scientific knowledge and outlook with subject matter and perspective that are truly current. The result is as astounding to the research biologist as to the high school teacher. How nearly fatal that until so recently no one seemed to realize that this must be the way, the only way, in an ever accelerating pace of scientific advance to provide the well-oriented education in the sciences that modern man must have.

"This is one answer to the question. The other is this. For the first time, I think education in the natural sciences, at least at the secondary level, has assigned the acquisition of scientific information and concepts a place of lesser importance than the understanding of the very nature of scientific enquiry and of the scientific enterprise in which modern man is embarked. As I wrote on an earlier occasion : 'The aim of the Biological Sciences Curriculum Study is to place biological knowledge in its fullest modern perspective. If we are successful, students of the new biology should acquire not only an intellectual and aesthetic appreciation for the complexities of living things and their interrelationships in nature, but also for the ways in which new knowledge is gained and tested, old errors eliminated, and an ever closer approximation to truth attained'. "

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NEW SCIENCE TEXTBOOK SPURS AUSTRALIAN SECONDARY EDUCATION

DON JOINSON

Sydney, Australia

Science for High School Students, a comprehensive science textbook that integrates the four basic sciences of physics, chemistry, biology, and geology, will be introduced to nearly 50,000 first-year secondary school students in the Australian State of New South Wales next year.

A product of some of the most able scientific minds in the state, the new textbook has been prepared under the direction of the Nuclear Research Foundation at the University of Sydney for the New South Wales Department of Education.

It is believed to be revolutionary in its concept of an integral scientific study.

Professor Harry Messel, head of the School of Physics at the University of Sydney, and director of the Foundation, instigated the compilation of the new textbook.

Its basic design is to serve the new and advanced syllabus that was introduced to the secondary schools of NSW last year. Under this new syllabus, every boy and girl has to take an integrated science course during the first four years of the six-year course of study, leading to the award after four years, of the School Certificate.

The first edition of the textbook—a pilot edition—has 880 double-column pages and more than 700 illustrations, including several in full colour.

The Nuclear Research Foundation has undertaken to distribute free copies to all science teachers and interested tertiary educationists.

In addition, 1200 copies will be distributed free to some 30 test classes in state and private schools.

Pilot copies of the book contain a detailed questionnaire, so that teachers and educationists can make comments and express views on the book's efficacy.

Research officers of the NSW State Department of Education will use the questionnaires to make a thorough examination of the new textbook's strengths and weaknesses.

By courtesy of the Australian High Commission, New Delhi.

The results of the investigation will help the editors and authors of the book in a revision at the end of this year (1963).

The Foundation is also producing a teacher's manual to accompany the first edition. The manual will be available to all teachers in the State.

All state schools in NSW will be provided with the textbook from the first term next year (1964). Private schools will decide individually whether to use the textbook, and most have already indicated their intention of doing so.

Keen international interest has already been aroused in the book.

Professor Messel himself will leave Australia within the next few weeks to negotiate reproduction rights with an interested United Kingdom publishing firm.

Preliminary talks have suggested the likelihood of the book being published overseas in four language editions, as well as in standard English. The languages are likely to be French, Spanish, German, and Hindi.

'Before translation, the book will need quite an amount of re-editing revising, and even re-writing,' Professor Messel said. 'While the sections on physics and chemistry are immediately suitable for international use, the sections dealing with biology and geology have local Australian examples and applications. For its full value to be realised in other countries, these sections will need careful editing and re-writing to give the appropriate local interpretations.'

Copyright of the book is vested in the University of Sydney on behalf of the Nuclear Research Foundation.

The price of the book has not yet been decided. It is not likely to be high, as the group of authors and editors—the Nuclear Research Foundation School Certificate Integrated Science Textbook Group—has renounced all royalties from the book's sale.

The group, comprising 28 Australian academicians, had four section leaders in their writing and compilation.

The chemistry group was led by Professor G. A. Barclay, Associate Professor of Inorganic Chemistry at the University of New South Wales; the physics group by Professor S. T. Butler, Professor of Theoretical Physics, University of Sydney; the biology group by Professor F.V. Mercer, Associate Professor of Biology at the University of Sydney; and the geology group by Professor A. H. Voisey, Professor of Geology at the University of New England, Armidale, NSW.

Professor Messel, in his introduction to the book, stresses that the book 'is for the youth of Australia and not just for the teacher'. He writes :

'It has been written in such a way that, if need be, a student could gain considerably from a study of the book without a teacher. However, the teacher is most essential to a proper teaching of the science course.'

Professor Messel, who conceived this idea for an integrated science textbook, took his idea to an enthusiastic NSW Department of Education in August, 1962. He proposed that a representative group of writers should tackle the task of preparing the science textbook. He offered the Foundation as the unifying force and said it would also ensure raising the finance, which was initially about £A 45,000.

The bulk of the money was provided by donations of £A 10,000 each from three Australian business sponsors- Ampol Petroleum Ltd., W. D. and H. O. Wills, and Woolworths Ltd.

Professor Messel, Professor L. Crocker, head of the school of Biological Science at the University of Sydney, Mr. O. A. Guth, executive assistant in the university's School of Physics, and Mr. L. Barker, staff inspector of the NSW Department of Education, formed the executive editorial committee.

The committee established a group of 28 science academicians in NSW to prepare draft manuscripts under their direction.

The division of editorial effort under expert supervision enabled the book to be prepared, written and produced in just 22 weeks. Its publication was treated as a matter of urgency to complement the Wyndham scheme which was introduced into secondary education in the state last year.

The Wyndham scheme, named after the Director-General of Education in NSW, Dr. H. S. Wyndham, began last year with the enrolment of 40,000 primary students into secondary schools.

Basically, the scheme extended the duration of the secondary education course in NSW from five to six years. It was devised to give greater scope for identification and development of a student's individual abilities, and to ensure a fitting scientific education to meet the complexities of 20th century living.

Students take common subjects for the first year, and are then graded according to ability. They continue to have a basic common curriculum for the next three years, but spend increasing time on special studies in suitable subjects.

The four-year science course for which the book has been prepared is part of the common curriculum and covers physics, chemistry, biology and geology.

The main examination to cover completion of the four-year secondary education course is an external School Certificate Examination.

Students who wish to continue studies at a university or other tertiary education institutions continue for another two years towards a High School Certificate Examination, designed as a University matriculation examination.

The book was launched in Sydney on May 3 this year at the ninth annual dinner of the Nuclear Research Foundation and has received a spate of favourable comment by leaders of Australian education.

The NSW Minister for Education, Mr. E. Wetherell, said the state's science syllabus was radically different from those followed in other parts of Australia and overseas.

'Before today, no one book published could cover adequately the needs of our new syllabus, neither in the contents nor in the spirit activating it,' he said. 'I am happy to say the Foundation's book does both. It captures the very spirit of our new science syllabus in every respect.'

The chairman of the Nuclear Research Foundation, Mr. T. J. N. Foley, said : 'The creation of this book is the biggest and the most important contribution to education with which the Foundation has yet been associated'.

The Australian Minister for National Development, Senator Sir William Spooner, described the book as one of the best things the Foundation had achieved.

ATOMIC THEORY AND THE ART OF WATCHMAKING

JACQUES BONANOMI

Department of Physics, Neuchâtel University

For centuries watchmakers have been building more and more reliable timepieces. Three hundred years ago a clock varying less than a second a day was still a dream of the future. A hundred years later it was a reality much admired by kings and emperors. Today you can get as much precision as that from a cheap wrist watch. Meantime the art of the watchmaker has developed pendulum clocks and chronometers capable of a precision of 1/100 of a second. The last-comers are the quartz clocks, which will vary less than 1/10 of a second in a whole year.

Nowadays time is the physical phenomenon which can be measured with the greatest accuracy. It is a hundred times easier to measure a second accurately than to measure an inch or a gramme. The length of a kilometre can be measured with the precision of one ten-millionth, the length of a day, however, with an accuracy of one thousand-millionth.

You may wonder what is the smallest fraction which can be measured and where the race for ever greater precision will end, since the physicist is not yet satisfied with 10 zeros after decimal. Twelve to thirteen of them are needed for testing Einstein's theory of relativity.

Physical science will allow the watchmaker no rest and ask him for ever more precise timepieces. At the same time it will show him the way to still better results. After all it is to physics that we are indebted for whatever technical progress has been achieved.

The invention of the watch which modern man carries about on his wrist or in his pocket is a legacy of the physical science of the past, of classical mathematics in particular. The watch of the future will probably be a child of to-day's physical science, i. e. atomic science, the study of atoms and molecules. But is it really possible to improve the best watches we have today? Let us hear what answer atomic physics has to this question.

First remember why our traditional watches are so marvellously precise. Let us see how they work, and let us distinguish between essential facts and nonessential ones. Finally let us look for possible shortcomings.

By courtesy of the Embassy of Switzerland.

Take first the pendulum clock ! Its most important part is evidently the pendulum which carries out the free swinging movement. All the rest serves but to keep up the movements and to record them on the dial. What is essential, therefore, is the free movement of the pendulum. The duration of one swinging movement is the unit of time of the clock. Our clock will go accurately and be reliable only as long as the swinging movements of the pendulum are always the same.

Now look at your wrist watch. Its swinging movements are due to the combination of the balance and the spiral. So we have again the method of measuring time by means of recording the number of oscillations or swinging movements, all of which must be of equal duration if the watch is to be reliable.

As a third example let us take the quartz clock, the most perfect timepiece of the present. Its essential steering organ is a free swinging quartz crystal. It is less essential that these swingings are very rapid (about 100,000 oscillations per second) and that they are due to and recorded by electricity. Most important is the fact that the oscillations of the quartz are almost perfectly regular, neither delayed nor intermittent, and almost unaffected by outside influences.

The three types of timepieces so far mentioned have one common characteristic, which we call 'resonance', i. e., continued movements of a free swinging system (pendulum, balance, quartz). It is the merit of physicists of former centuries to have found out that a good timepiece must be steered by resonance. This principle still holds good.

But with all their qualities the above described systems have two drawbacks. In the first place they are not absolutely invariable. They are subject to alterations under such influences as temperature, age, etc. Secondly, it is not possible to construct two absolutely equal systems, two pendulums, for instance, of exactly the same length. Therefore, if we want to improve the accuracy of present day clocks and watches, we must find a swinging system the movements of which are influenced neither by temperature nor by age, and of which any number of absolutely identical copies can be reproduced. Where shall we find such an apparatus?

The new atomic theory can give a clear reply to this question. Atoms and molecules possess the very qualities we are looking for. They know neither temperature nor age, and all of the same kind are absolutely identical. But there remains the question whether atoms and molecules can carry out resonance oscillations. Of course they can. This is the fundamental evidence of the atomic theory. This leads us to the atomic chronometer on the construction of which scientists are working in various laboratories.

The principle of the atomic timekeeper under construction is as follows: First there must be a steering organ. Let us take the ammonia molecule. Ammonia is a gas, i. e. an aggregation of small, freely moving molecules, each of which is composed of three atoms of hydrogen and one atom of nitrogen. The latter oscillates. When it is stimulated it will swing to and fro 23,870,120,000 times a second. Thanks to the radar technique it has recently become possible to measure oscillations of such frequency. In order to stimulate and maintain the oscillations, the ammonia must be irradiated by radar waves, the frequency of which exactly corresponds to that of the nitrogen oscillations. Then the oscillations are registered by a delicate receiver which in its turn steers the radar waves.

The practical construction of the atomic watch now simply consists in counting the molecular oscillation of the ammonia on a dial, for instance. In reality the problem is, of course, much more complicated, but the results obtained so far are quite encouraging.

The duration of a molecular oscillation being absolutely invariable, all atomic watches based on this oscillation will be synchronized at all times. Thus the atomic chronometer will be the basic or standard time keeper by which all the other watches and clocks can be set. Similar to this we have already got the original or standard metre, by which all the other metric measures are controlled. Even the original standard metre has recently been checked and re-defined on an atomic basis.

Our daily lives and our traditional clocks and watches will hardly be influenced by the atomic watch. But in physical science it is important to have found a solid basis for determining the second, the unit of time which figures in so many formulas.

The conventional basis of our timing system is still the earth, though various objections have been made to the system. From the duration of the rotation of the earth around its axis we have deduced the second, our present unit of time. But we now know that the rotation of the earth is not perfectly regular, and that it is subject to change in the course of time. Therefore, in future we had better ask the atom, and not the earth, how long a second really is.

HIGHER TECHNICAL EDUCATION IN BULGARIA

I. GARGOV

Bulgarian Information Bureau, Bulgaria

Should you ask any Bulgarian engineer of the older generation where he received his education, he will undoubtedly answer : Germany, Czechoslovakia, France, etc . . . As a matter of fact, up to 20 years ago Bulgaria did not have a single higher technical school. The young Bulgarians who wished to become engineers were bound to go abroad. A great many of them fulfilled their ambitions at the price of privation, material difficulties and discomfort. It was not before 1942 that Bulgaria opened the first higher technical school whose only department (of civil engineering) enrolled 122 students. The following year saw the opening of a department of agriculture.

Higher technical education, however, began to develop rapidly after Bulgaria's liberation from fascist rule and imperialist dependence in 1944. Many new departments were opened and the material basis of the state polytechnic school was improved and extended. In 1953 the school was divided into four independent institutes, and a little later, several other higher technical schools were opened to meet the needs of the country. Today Bulgaria has seven specialised institutes for the training of engineers, five of which are in Sofia. They cover the following subjects : mechanics and electrotechnics, civil engineering, chemistry and technology, mining geology, forest engineering. mechanization and electrification of agriculture (in the the town of Rousse'), food and beverages (in Plovdiv). Nearly 30,000 students are educated in them in 59 subjects, and 8,460 of them are studying by correspondence courses, being workers, employees and co-operative farmers. Extramural education is equivalent to the regular course. The Bulgarian technical schools are also educating boys and girls from 52 foreign countries, mainly from the newly liberated ones.

In most subjects the course is 11 semesters and in some 9 or 10. On finishing it, the students receive a degree in the given field. Every year the Bulgarian higher technical schools produce 1,500 well-trained mechanical engineers, electrical engineers, civil engineers. architects, mining engineers, chemical engineers, and so on, who immediately join the different branches of the national economy and science.

Hundreds of new works and factories owe their existence to the

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By courtesy of the Embassy of the People's Republic of Bulgaria creative e'lan of Bulgarian engineers and architects and so do numerous industrial and housing complexes, the excellent Black Sea resorts of Golden Sands, Sunny Beach, dozens of up-to-date hotels, dams and power plants, administrative buildings, nurseries, and so on.

But the skill and ability of the Bulgarian designers and constructors are not known only in this country. They are highly appreciated abroad. Bulgarian architects have won competitions for the reconstruction of Tunis and the centre of Berlin, and for working out plans for a number of cities in Syria. Bulgarian engineers have done a great deal of construction work in Iraq, Syria, Ghana and other newly liberated countries.

These successes of the Bulgarian engineers and architects are perfectly natural and logical, when it is borne in mind that as many as 2,000 professors and lecturers have taken care of their education. Among these are distinguished scholars and corresponding members of the Bulgarian Academy of Sciences, such as Professor Engineer Yakim Yakimov, Professor Engineer Angel Balevski, Professor Architect Lyuben Tonev, Professor Engineer Dimo Velev, Professor Engineer Ivan Popov, and so on.

Students are guaranteed good living conditions and everything else that is necessary for careful scientific study and cultural life. In the first place, they do not pay any fees for accommodation and examinations. (In Bulgaria education is free of charge). Nearly half the students receive state scholarships which satisfy their major material and cultural needs. Many students of the higher technical schools live in students' hostels free of charge, and receive nourishing, highly caloric and popularly priced food at the students' canteens. They have numerous comfortable reading rooms, rich libraries as well as laboratories and studies equipped with modern machines and apparatuses.

The accelerated economic development of the country in the last few years has set new tasks before the education of specialists in the different branches of the national economy. The number of students and specialities in the existing institutes is to be increased every year and, parallel with this, the network of higher technical schools is to be further extended. For example, a new institute of mechanics and electrotechnics is to be opened in Varna, including three departments : machine-building, electrotechnics and ship-building. A new institute of chemistry and technology is to be opened in the town of Bourgas which will train specialists for the chemical industry and oil processing. Early in the academic year of 1964—65 an extramural general technical school is to be opened in the industrial town of Gabrovo with a three-years' study course. This course will cover the general technical subjects, after which the students will continue their education in the specialized technical schools.

According to the long-range programme for the country's development in the next 20 years, by 1980, 55-60 per cent of the students enrolled in the higher educational institutions will be studying engineering. And the number of specialists with university and college education employed in the national economy will rise from 117,200 in 1960 to about 450,000 in 1980, 150,000 of whom will be engineers. For Bulgaria, which has a population of eight million, this will constitute a vast army of highly competent specialists who will pour their knowledge and energies in building our new life.

YOUNG FOLK'S CORNER

SCIENTISTS YOU SHOULD KNOW

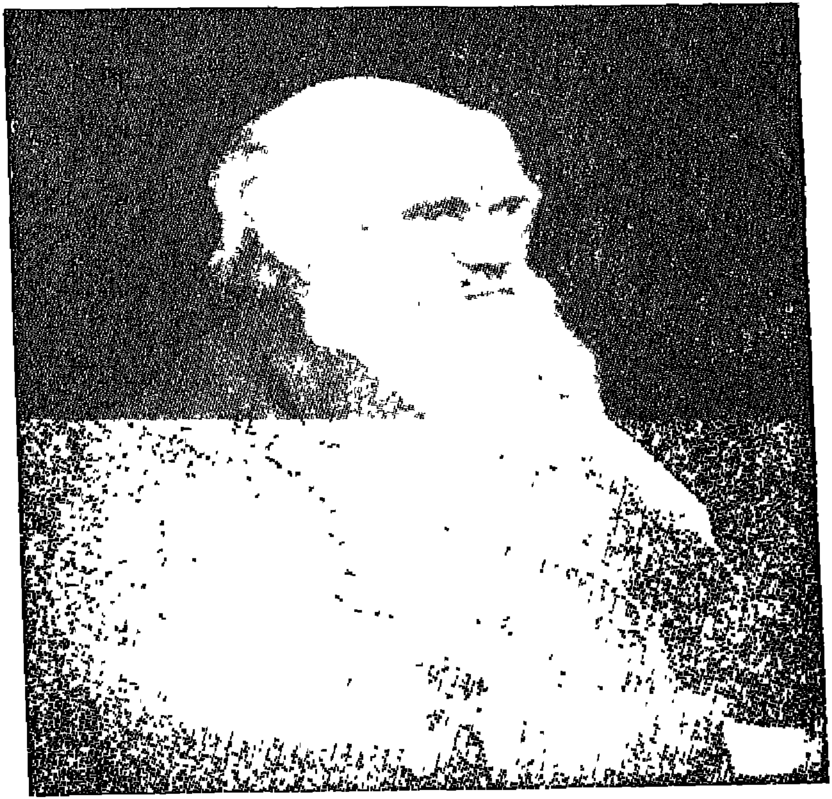
CHARLES DARWIN (1809-1882)

February 12, 1809 was an eventful day for the history of mankind. On that day were born two persons who have left indelible marks on history and science. One was Abraham Lincoln in America and the other was Charles Darwin in Shrewsbury, England. While the former became great as the champion of freedom and liberty, the latter became famous by the book he produced in 1859. It was called *The Origin of Species by Means of Natural Selection* through which Darwin put forward his ideas on the evolution of plants and animals from simple forms by a process of slow, and gradual change. No book published in the nineteenth century started a bigger controversy and protest than this one. The idea of evolution as propounded by Darwin was so revolutionary that even now there are a few who feel it cannot be accepted. To any boy who has studied some biology, the word evolution brings up pictures of the ape and Darwin, the latter as the author of the idea that man is descended from ape-like creatures.

Darwin at school was not considered brilliant by his teachers. He was slow in learning and showed greater interest in natural history, collection and shooting. He was quite a simple lad and humane. He would never collect more than one egg from a bird's nest. He would collect anything : shells, pebbles, stamps, dead beetles and birds' eggs.

Darwin took great interest in the laboratory set up by his brother in their house. He assisted his brother and read many works and considered this period to be his best in education. But finding the boy backward, Darwin's father took him away from school and sent him to study medicine. Here Darwin found the lectures very dull. He was averse to direction and incapable of drawing well. He could not stand the sight of operation and once ran away from the operation theatre.

Once again finding his son not taking interest in his studies, Robert Darwin, the father, proposed that Charles should become a clergyman. For this he had to take a degree, and so he went to Cambridge. Even here Darwin's interest lay in shooting and collection. His passion for the latter was so great that his delight was boundless when he saw in Stephen's *Illustrations of British Insects* the words, 'Captured by C. Darwin, Esq.' But on leaving Cambridge with an ordinary B. A. degree, he did not become a priest.



CHARLES DARWIN (1809-1882)

About this time a brig, *H. M. S. Beagle*, was about to sail round the world to make a survey of the lesser known coast-lines and waters. Fitz Roy, the captain of this boat, wished to take an unpaid naturalist with him. Professor Henslow recommended Darwin's name, much to the latter's enthusiasm. But his father would not agree and later permitted him only on the intervention of Charles' uncle. So the *Beagle* sailed on December 27, 1831, on its historic voyage, which was to make the ship and its captain famous. The voyage lasted for five years during which Darwin found a consummation of his favourite interest of collection and an opportunity to observe nature and the living creatures in it.

Throughout the voyage and in spite of his sea-sickness, Darwin collected specimens, observed that the species of plants and animals changed as he went from one part of land to another, and that they yet possessed very remarkable similarities. He also studied the geology of the continents and islands he visited. He took voluminous notes and shipped home these as well as his collections periodically. His notes roused the interest of his friends back home among whom many were biologists. These made him quite a noted personality among the scientists.

The Galapagos islands lying on the Equator, 500 miles West of Ecuador, was a paradise for his study and collections, but to most, the islands were not particularly a place for holiday. The islands were a home of crabs, lizards and giant tortoises. The birds here showed great differences in structure from those on the mainland. The tortoises were a different species from those on the American mainland. So was the case with the birds and plants. But they still had some resemblances to those of America. Charles reasoned that at a remote period the ancestors of these plants and animals had gone over from other places to these islands and they had gradually changed and branched out into a number of species. All this meant that species did *change*. This was quite contrary to the widely held belief at that time that each species had been specially created in the beginning by the Creator and that these species never changed. But Darwin kept this idea to himself even after the *Beagle* returned to England on October 2,1836.

Soon after his return he became afflicted with a strange illness and moved away from London. He worked hard on his notes and the further collections he made. He reached the conclusion that since variations existed in individual characteristics among members of any species, selection of some individuals and elimination of others were the solution to organic change. The struggle for existence under changing conditions induced alteration in the structure of organisms. There was selection in nature—the survival of the fittest. Any species that got a slight advantage over other strains survived in the struggle for existence.

The unfit were eliminated. He called this Natural Selection. For 20 years Darwin delayed publishing his results in spite of the goading of his friends, till he received a letter from one A. R. Wallace enclosing a paper written by him. Darwin got a jolt when he found that Wallace held the same views about species as his own. Wallace came to this conclusion independently of Darwin, while on a collecting trip in Indonesia. Generously, Darwin offered to withdraw in favour of Wallace. But his friends Lyell and Hooker arranged for a simultaneous delivery of the views of these two before the Linnaean Society.

When *The Origin of Species* was published in November 1859, all the books were sold in a single day. The book that came out with such a tardiness turned out to be one of the greatest books of all time. The theory —Darwinism—found easy acceptance among scientists and most of the public. But it created a storm among the religious minded who could not brook any variance from the view that all animals and plants were created at the same time by the Creator. Least of all could they countenance the probability that man could have evolved from ape-like ancestors. The storm broke out at a large meeting at Oxford. Speaker after speaker attacked Darwin who was incidentally ill and could not be present at the meeting. Huxley defended him strongly. The greatest critic Wilberforce, the Bishop of Oxford, ridiculed the theory and asked Huxley whether he claimed descent from an ape on his grandfather's or on his grandmother's side. Huxley retorted by saying that he would rather have an ape as his ancestor than a man who instead of doing his duties, interfered in scientific matters about which he knew nothing. But within a decade every scientist believed in evolution and religion had to be reconciled with it.

Darwin's theory was not quite new. Others before Darwin had tried to explain the variations and the similarities between organisms. Darwin's grandfather Erasmus Darwin, famous in his own way, believed in a sort of evolution.. Lamarck, born 65 years before Darwin, had held the same views. But Darwin looked at the problem in a scholarly way. With a mass of observations he proved that evolution was the pattern of life itself.

Darwin died in 1882 and was buried in Westminster Abbey.

S. DORAISWAMI

TEST YOUR KNOWLEDGE

Why does a cut finger heal quickly ?

Every day layers of dead skin are rubbed off and replaced by the layer underneath. Throughout life, the under layer of the skin continually creates new cells. This is one of the reasons why a cut on the finger heals very quickly.

What is a bathyscaphe ?

Bathyscaphe is a depth ship, which makes it possible for scientists to descend to the ocean floor and explore it.

What is the green colour on Mars ?

It is probably vegetation. The green areas on Mars are faint and delicate during the Martian spring, they grow much darker and in some cases almost a blue-green in the Martian summer, yellow and brown in the fall, and a rather lifeless gray in the winter. The green regions are not probably grass or trees as they do not show the same sort of reflection of light that is produced by a plant with chlorophyll. The vegetation may be lichen which can grow on very little soil and under very dry conditions. Another theory holds that the green substance may be volcanic dust. The drifting and shifting of this dust in the light breezes that are all the rare atmosphere of Mars can produce, accounts for the colour change.

Of what is synthetic diamond made ?

Synthetic diamond is composed of carbon, as is the natural mineral. The source of carbon in many of the synthetic diamonds of industry is likely to be of organic origin, such as sugar. Sugar was used in earlier experiments in synthesizing diamond by Henri Moissan, Sir William Crooks and Sir Charles Parsons.

What role does vitamin A play in sight ?

Vitamin A plays an important part in keeping the eye healthy. The malady, *night-blindness*, is due to the poor functioning of the peripheral areas of the retina. This can be cured by vitamin A. A number of chemical reactions go on in the eye, in which a red dye-like substance called *visual purple* renders the retina sensitive to light. This material is broken down by the light and must be synthesized again by taking vitamin A and other chemicals supplied by the blood.

What is Radar

RAdio Detecting And Ranging is the first name from which RADAR is derived by taking the letters in capitals from the different words. With the help of radar, man can look through fog and darkness. A ship's captain looking at a radar will see little spots of light on a screen or scope while his own ship will be shown as a blob of light in the centre of the screen. The other spots indicate objects around the ships. The number and letters on the screen tell the captain how far away these objects are. The radar gives warning about other ships or icebergs. A pilot on a plane can know where other planes are and he can locate landing fields even through clouds, fog and pitch darkness. Radar on the ground can locate planes in the air.

How does a radar work ?

A part of the radar transmits or sends out radio waves. When the waves hit a solid object they bounce back. The returned waves are picked up by another part of the radar which changes radio waves into light, and spots of light appear on the radar screen.

Radio waves travel as fast as 186,000 miles per second, but a radar is quick enough to measure the time that waves take travelling out to an object and back again, and also reckon how far away the object is. A light appears immediately on the screen showing the distance to the object and the direction in which it is located.

Why does glue stick things together ?

Glue, like everything else, is made up of molecules. The molecules attract neighbouring molecules. A glue molecule attracts those of paper and wood. The attraction is stronger when the glue is dry. The molecules pull hard on each other and on the materials meant for sticking and so make them stick tight.

There are various kinds of glue. Some attract wood or paper. Others attract China or glass. One kind of glue is made from the hoof and horns of animals. Varieties of glue can also be made from rubber and milk.

Is a jet engine the same as a rocket ?

The jet and the rocket gather speed by the push that they get from the exhaust gases which are moving backwards with great velocities. Both need oxygen to burn their fuel. The jet gets its oxygen from the atmosphere. But the rocket goes far into space where there is little air. Therefore, it carries its own supply of oxygen.

Do you know ?

- The tufts on the giraffe's head are actually rudimentary horns.
- The giraffe relies on its keen sight to warn it of danger, and on its speed to remove itself from it.
- The biggest tree in the world belongs to the genus *Sequoia* named after a famous American Indian. There are two kinds of *Sequoia*. *S. gigantea* (Big Tree) and *S. sempervirens* (Red Wood). The former is named 'General Sherman'. It is 272 ft. high, 36½ ft. in diameter at the base and nearly 115 ft. in circumference. Scientists believe that 'General Sherman' is already 4000 years old and may live for another 2000 years. At present these trees are found on the slopes of the Rocky Mountains in the United States. The Red Wood is even taller than the Big Tree, and is nearly 365 ft. high but is less in diameter at the base. They grow along the Pacific coast of the United States, north of San Francisco, and the biggest of them are over 2000 years old.
- The bees have a strange language by which they communicate with other bees in the hive and tell them about a new source of food. This language is in the form of dance—the 'round dance' and the 'wagging dance'. Karl Von Frisch, an Austrian zoologist was the first to describe this language of the bees and its meaning
- The stomach in the cow is a large four-chambered organ. Food is eaten and swallowed. It passes down the oesophagus to the first chamber of the stomach. From time to time it is brought up and chewed—a process called 'chewing the cud'.
- The ostrich, a 300 lb. bird, is the fastest thing on two legs, capable of running fifty miles an hour.
- Malaria is transmitted through the bite of a female mosquito. The male cannot suck blood because he lacks piercing mouth parts. In the female some of these parts are modified to form a piercing and sucking tube.
- It only takes 1.3 seconds for light reflected from the moon to reach the earth.
- The human skin grows faster than any other part of the body and never stops growing even though it gets no bigger once it has reached its full size.

SCIENCE NOTES

INDIAN BEETLES TO WAGE WAR ON AUSTRALIAN PLANT PEST

An Indian beetle, *Nupferha antennata*, has been selected to spearhead an attack in the continuous war Australian agricultural experts wage against vegetable and insect pests.

The Director of the Biological Section of the Queensland Lands Department (Mr. J. Mann) left Brisbane this week to spend four months in New Delhi where he will collect 20,000 beetles for the 1964 campaign against Noogoora burr, *Xanthium chinense*, the detachable spiny fruits of which cause an annual wool loss of at least £ 50,000.

Mr. Mann visited India in 1957 and collected 15,000 of the beetles which were used for tests against different destructive plants.

These tests proved so successful against Noogoora burr under caged conditions that they will now be used for extensive field work in 1964.

Nupferha antennata is a stem-boring beetle which destroys the burr or reduces it sufficiently to enable control methods to become effective.

The beetles will be imported from India as larvae in the roots of Noogoora burr and held under quarantine in the Queensland Lands Department's biological laboratories pending their emergence in the summer of 1964.

Their release in the field will be made following permission by the Federal Department of Health.

Mr. Mann regards the project as a positive approach to tackling the ever-present problem of Noogoora burr.

The burr, which is indigenous to North America, is supposed to have been introduced into Australia with cotton seed. Since 1860, it has occupied sheep country from Sydney to the Gulf of Carpentaria in the north of Queensland. It is poisonous in the seedling stage and has caused mortality among sheep, cattle and pigs, but the nature of the toxin is not yet understood.

The mature growth tangles in the wool and depreciates the value of the clip.

By courtesy, Australian High Commission, New Delhi.

WORLD NEED FOR PROTEIN MAY BE MET THROUGH THE HARVEST OF FUNGUS

The annual protein requirements of 1,400 persons could be met by the harvest of fungus from one 50,000-gallon (190,000 litres) culture tank, according to an Ohio State University mycologist who has developed a system of protein synthesis by fungi.

Dr. William D. Gray, Professor of Botany and Plant Pathology, reports that a yield of fungal tissue high in protein content could be harvested from the tank every 48 hours.

The harvested tissue would have the appearance of cooked tapioca or caviar and would be virtually odourless and tasteless. It could be dried and ground to a flour or formed into flakes or pellets. It is not being proposed for direct human consumption at this time, but may prove useful as a source of protein for feeding livestock.

Dr. Gray, who views the world's food shortage as primarily a protein shortage, has been experimenting for the past three years with the synthesis of protein through the use of Fungi Imperfecti, a class made up of thousands of species of fungi.

In its simplest form, the small scale laboratory system devised by Dr. Gray, converts carbohydrate, which is in great excess in the world, and inorganic nitrogen into approximately one-sixth their weight of protein. Since a total synthesis of protein is involved, any protein so formed represents a *net gain,* he explains.

By courtesy, United States Information Service, New Delhi.

BRAIN SIGNALS TRANSMITTED VIA TELSTAR

A solar radio system network making immediate medical advice available in the world merely by dialling a telephone number is forecast by British scientists.

History was made at the week-end when brain signals were transmitted across the Atlantic by way of the Telstar communications satellite.

Signals transmitted over Telstar by Dr. W. Grey Walter, of the Burden Neurological Institute at Bristol (England), were received by Dr. Reginald Bickford, of the Mayo Clinic, Minnesota (USA). These were of a patient's brain reactions to clicks and flashes of light transformed into telephone signals. The signals were then transmitted *via* Telstar to the United States, where they were analysed in a few seconds and the results sent back to Bristol almost immediately for comparison.

Dr. Grey Walter said : 'If we can rely on this type of link, it means that application of very sophisticated and often expensive techniques (computation and analysis) will be possible from research centres anywhere in the world.

'We hope that in the future there will be a worldwide network of such computer services available simply by dialling a telephone number.'

By Courtesy, British Information Services, New Delhi.

CANADIAN SCIENTISTS STUDY SECRETS OF THE SEA

A neglected branch of scientific exploration but a few years ago, oceanography in Canada is now one of the newest, most exciting and vital fields of discovery With the longest national coastline in the world, bounded by three oceans and myriads of islands, large and small, Canada has a natural urgent interest in oceanography the scientific study of the mysterious sea and all its wonderful ways On the Atlantic coast near Halifax, Nova Scotia, has been built the Bedford Institute of Oceanography which with a staff of nearly 300 scientists and its own ocean fleet has embarked on a five-year programme laid down by the Canadian Committee on Oceanography, representing the federal agencies and interested universities

Food potential, mineral wealth, effects on man's environment, probable uses for the future--these are the reasons why scientists are now looking deep beneath the rolling waves and heaving swells of ocean waters, probing through ice-covered waters in polar regions. Studying samples of water, marine life, seabed rocks and silt, physical changes, temperature, chemical characteristics --this is how scientists are gaining their knowledge.

The scientists include physicists, biologists, hydrographers, geologists, meteorologists, chemists and technicians. They will range Canada's blue, green and frozen white oceans, study their physical-chemical properties, investigate the life they contain, the riches they hide. They will delve into the depths, scrutinize the ocean bed, observe the mechanics of water masses, study effects on the atmosphere, then, in the laboratories of the new Bedford Institute of Oceanography, study in detail the samples and information they collect, unravel the secrets of the last unknown frontier left on planet Earth. They will probe the sea's commercial use, defensive strength, far-reaching effects of mankind, provide Canada's scientific contribution to international studies of the world's seven seas and generally cover the spectrum of the science of oceanography.

The hydrographic service is a Marine Sciences Branch of the Department of Mines and Technical Survey, with a fleet of nine ships, 65 launches, a stock of 800 different charts and 14 volumes of sailing directions and other special publications.

The Director of the Bedford Institute is 46-year old, Dr. W. N. English, an authority on marine physics, and the head of the new branch is Dr. Willian Cameron, an international authority on oceanography and former chief of the oceanographic research division.

Compiled from the literature kindly supplied by the Canadian High Commission, New Delhi.

NEW METHOD PUTS WATER WHERE MOST NEEDED TO BOOST CROPS

Scientists of the United States Department of Agriculture are growing plentiful crops with scant rainfall in a soil and climate where previously this had been impossible without irrigation. This has occurred in south central North Dakota, an area of the north central Great Plains where agriculture has been limited largely to grazing and irrigated crops. Substantial crops of corn (maize) and other crops requiring moisture volume not usually available here were raised on test plots with available rainfall by diverting available moisture to the plant itself

The research specialists covered ridges of soil between corn (maize) rows with strips of plastic film. This covering caused what moisture fell to roll down the ridges into the corn rows, concentrating enough water on the crop plants to allow good growth.

Materials such as the plastic film used are too costly now for farmers. So the next step is to devise a covering cheap enough to make the operation feasible and as efficient as the plastic in controlling moisture.

A 50-bushel per acre yield was secured in the tests. The area where the tests were made is nearly as far north as corn can be grown for grain in the United States.

Crop yields always have been erratic in this Great Plains area because rainfall is often inadequate or it fails to come when growing plants need it most. The scientists therefore sought ways to conserve what limited rainfall occurred both through restricting evaporation and increasing the infiltration of available water into the soil where it was most needed.

The test plots used were so cultivated that soil ridges three inches high paralleled the corn rows. Ninety per cent of the ridged area was covered with black polyethylene plastic film. Corn was planted in the uncovered ten per cent between the plastic strip-covered ridges. Film-strips were 38 inches wide, and rows were 42 inches apart.

As the result of the soil and plastic strip arrangement, rainfall and even dew largely drained off the covered ridges and was concentrated in the ten per cent of the soil that was bare. When a quarter-inch rain fell, the uncovered furrows containing the row of corn plants received the equivalent of a 2.5-inch rain.

The researchers declared that the better production on the covered-ridge plots resulted from (1) more efficient use of light rains, (2) better use of increased soil moisture in the corn rows, and (3) higher soil temperature, which stimulated germination and seedling growth.

By courtesy, United States Information Service, New Delhi.

NEW U. S. COMMUNICATIONS SATELLITE USES PRECISION CONTROLS

The United States embarked last week on the most exacting experiment in precision control of a satellite ever attempted with the launching from Cape Canaveral of SYNCOM II.

The cylinder-shaped space vehicle was sent skyward with a Delta rocket which has now rung up its 19th straight successful launching.

Scientists of the U. S. National Aeronautics and Space Administration said the mission appeared 'completely normal'. The satellite is to be the first space communications link between Africa and the United States.

But before this can occur, SYNCOM must complete a series of highly intricate and unprecedented manoeuvers within the next several days.

The plan calls for positioning SYNCOM above the Atlantic Ocean near South America in such a way that the satellite will appear to remain there almost continuously in contrast to prior communication satellites which were only serviceable for this purpose while they were orbiting nearby.

The Delta rocket boosted SYNCOM into an egg-shaped, 'elliptical' orbit at an altitude of about 140 miles (224 kilometers) above the earth. But at its highest point, this orbit reached an altitude of 22,548 miles (36,077 kilometers).

SYNCOM needed 5 hours 33 minutes to reach that altitude. Then a small motor on the satellite fired in order to put it into a circular orbit and maintain a constant altitude.

The next manoeuver is for the craft's own control system of nitrogen and hydrogen peroxide jets—a new approach to spacecraft altitude control—to move the spacecraft gradully over a period of several days to its permanent location over the Atlantic near South America. The jets will also be used to turn the craft so that its antennae will point in the most favourable direction for the trans-Atlantic communication.

During preliminary tests, the glittering spacecraft demonstrated its capabilities by receiving and beaming back to earth a recording of music, plus a voice tape and a teletype message. The satellite can also transmit telephone calls, but not television.

This experiment was carried on from aboard the 11,000-ton United States satellite communications ship Kingsport, anchored in Lagos Harbour through the cooperation of the Government of the Federation of Nigeria. The Kingsport is expected to use the satellite after its proper positioning to exchange messages with a ground station at Lakehurst, New Jersey.

Because SYNCOM orbit almost coincides with the rotation of the earth, the satellite is said to be 'near synchronous' space vehicle.

The earth at the equator rotates on its axis at 1,040 miles (1,664 kilometers) an hour. SYNCOM, because of its high altitude, must race faster—6,878 miles (11,000 kilometers) an hour—like the runner on an outside track, to keep pace and remain over one global location.

SYNCOM will not be 'anchored' exactly over one point. It will move 30 degree north and south of the equator, but only very little east or west. As a result, its course, if it were visible from earth, would resemble an elongated figure '8'.

By courtesy, United States Information Service, New Delhi.

NEWS AND NOTES

THE COMBINED BOOK EXHIBITION OF SCIENCE BOOKS

An exhibition of science books was held for five days from July 27 to 31, 1963, in the All India Fine Arts and Crafts Society Hall, Rafi Marg, New Delhi. The purpose of the exhibition was to bring to the notice of students of schools and colleges, teachers of science, scientists and interested public, a large number of recent publications on scientific topics. Over 800 books were displayed covering a wide spectrum of the field of science, ranging from astronomy and archaeology to palaeontology, space flight and missiles. The collection presented not only texts and reference books but also books that provide reading for pleasure, books that stimulate in young minds an interest in learning the why and how of science. Thus the treatment catered to the interest of children, laymen and the scientist.

The Combined Book Exhibitions are held annually in the United States, in a number of academic fields at different educational levels. The present collection, which formed the Combined Book Exhibition of 1962 was presented to the National Council of Educational Research and Training, by the Asia Foundation to serve as reference material and to be housed in the Department of Science Education. Eighty two leading publishers have contributed to this collection.

The exhibition was inaugurated by Shri P. N. Kirpal, Secretary, Ministry of Education and Director of the National Council of Educational Research and Training, on July 27, 1963, before a large gathering. The exhibition was very popular with school children who came in several batches. Several members of the public also evinced keen interest and some came a second and a third time also. The exhibition was moved from August 2 to 5, 1963, to the Delhi Polytechnic for the benefit of schools and the public of Old Delhi. The books are being taken round to different cities in the country for display to groups of teachers, educational workers and others interested in science education for young people. From August 22 to 26, 1963 the exhibition was held at the Constructive Training College, Lucknow, where it was declared open by Acharya Jugal Kishore, Minister of Education, Uttar Pradesh. The books were sent to Ahmedabad for the same purpose in the first week of September.

About 750 of the books are very attractively got up and well-bound. The rest of them are 'paper backs' which are naturally cheaper but which nonetheless retain all the good features of the bound books. A bibliography of these books has been published which will be a useful reference for the interested, in either selecting some books for their own collections and libraries or in consulting these books in a library.

SCIENCE TALENT SEARCH, 1963

A pilot study of Science Talent Search was conducted in the Territory of Delhi during the year 1962-63. Higher secondary and senior cambridge students from 87 institutions participated in the tests that were held on April 30, 1963. In all 371 students appeared in the tests and 80 students in the order of merit selected on the basis of the marks secured in the Science Aptitute Test and Essay Paper were called for interview conducted by a committee of experts. Dr. D. S. Kothari, Chairman, University Grants Commission, acted as the Chairman of the Interview Committee and the interviews were held at the office of the University Grants Commission on July 11 and 12, 1963. Sixty candidates appeared for the interview and out of these the ten top students were selected for award of scholarship and certificate of merit and another seven for the award of certificate of merit only. Two conditions had to be fulfilled for the award of scholarships :

1. The student must be admitted to a College or University for pursuing higher studies leading to a degree in basic sciences.
2. He must not receive any other scholarship of any denomination.

The amount of the scholarships will be Rs. 50/- p. m. for one year (commencing from July, 1963), and Rs. 75/- p. m. for the next two years. In addition to the scholarships, the above candidates will also be eligible to receive a certificate of merit.

It is intended to follow-up the career of the awardees of scholarships as well as of those who have received certificates of merit. Alongside, it is proposed to hold a workshop in the first week of October 1963, where the talented students will be brought in contact with eminent professors of India to work out their research plans.

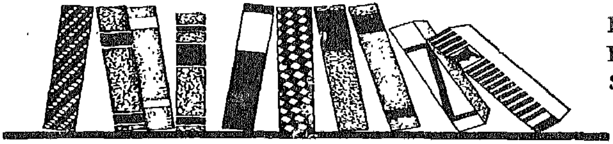
The scheme is proposed to be extended to other states and territories of India in the subsequent years.

The statement below gives the names of those who were declared eligible for the scholarships and the certificates of merit, the schools in which they studied, and the colleges they have since joined.

Name	*School*	*College*
1. L. Sarangan	M. E. A. H. S. School, Lodi Estate, New Delhi.	Hansraj College, Delhi.
2. R. K. Aggarwal	Harcourt Butler H. S. School, New Delhi.	College of Engineering, Hauz Khas, New Delhi.
3. Kanwal Nath	St. Columbas High School, New Delhi.	St. Stephen's College, Delhi.
4. Amit Roy	Union Academy H. S. School. Raja Bazar, New Delhi.	Hindu College, Delhi.
5. Geeta Trivedi	Lady Irwin H. S. School, New Delhi.	Hindu College, Delhi.
6. Prabha Bapat	Queen Mary School, Tis Hazari, Delhi.	Ferguson College, Poona.
7. Parthasarathy Bhattacharya	Raisina Bengali H. S. School, New Delhi.	St. Stephen's College, Delhi.
8. R. K. Raman	M. E. A. H. S. School, Lodi Estate, New Delhi.	Ramjas College, Delhi (casual).
9. R. Krishnan	,,	Govt. Polytechnic, Delhi.
10. K. Sampath	,,	St. Stephen's College, Delhi.

The following will receive certificates of merit :

1. Amitava Sen	St. Columbas High School, New Delhi.	College of Engineering, Hauz Khas, New Delhi.
2. Prodipta Ghosh	Delhi Public School, New Delhi.	,,
3. Anil Kashyap	,,	,,
4. Arun Kumar Sanwalka	Ramjas H. S. School, No. 5, New Delhi.	,,
5. Sunil Sethi	Delhi Public School, New Delhi.	,,
6. Suman Sain	Lady Irwin H. S. School, New Delhi.	Hindu College, Delhi.
7. Sudhir Kumar	Ramjas H. S. School, No. 5, Ramjas Road, New Delhi.	College of Engineering, Hauz Khas, New Delhi.



BOOKS FOR YOUR SCIENCE LIBRARY

Science : A Search for Evidence. A Unified Program in Science. BERNARD, J. D. *et al.* The Macmillan Science-Life Series. Macmillan Company, New York : 1960. $ 4.36, pp. ix+422.

This is one of three volumes which constitute the Macmillan Science-Life Series. The contents of this volume are divided into 11 units such as : 1. Evidence ; 2. Forecasting the weather ; 3. Heredity ; 4. Growth and learning ; 5. Sound, light and electrical energy ; 6. Energy and motion ; 7. Understanding the universe ; 8. Minerals of the earth ; 9. Plant life ; 10. A healthy body ; 11. Fighting against disease.

Each unit is introduced as problem-posing questions and these are answered in well-illustrated simple accounts. These include some simple experiments and end with suggested activities. After the problems follow *Unit Review* and *You can go Further*, where questions are framed and suggestions given for further investigation, reports and readings.

Science : A Way to Solve Problems. A Unified Program in Science, BERNARD, J. D. *et al.* The Macmillan Science-Life Series. Macmillan Company, New York : 1960. $ 4.52. pp. ix+422.

This is the second in the series. The matter is dealt with in the form of ten units. These are : 1. How scientists solve problems ; 2. The world's food supply ; 3. Energy ; 4. New products from chemistry ; 5. Heat, light and materials for building ; 6. Workings of the human body ; 7. How scientists predict behaviour ; 8. Soil and water ; 9. Aviation ; 10. Navigation.

Under each unit there are several problems stated in the form of questions and answers. The latter are full of facts and explanations and are well illustrated. At the end, there are a few suggested activities. The unit closes with a *Unit Review* and *You can go Further*.

Many principles and phenomena of several sciences are covered in this programme and the book is a good resource material to teachers.

Science : A Key to the Future. A Unified Program in Science. BERNARD, J. D. *et al.* The Macmillan Science-Life Series. Macmillan Company, New York : 1962 $ 5 52 : pp. vii+632.

This is the third volume of the series and it is a total programme in science. It is based in part on *The New Basic Science* (1956) by the same publishers. The subject matter is in the form of 10 units each with a number of problems or topics. The units are : 1. Science and the future 2. Matter and energy ; 3. Power to do the world's work ; 4. Radiant energy ; 5. Electricity and heat ; 6. The universe ; 7. Weather and climate ; 8. Living things ; 9. Human beings ; 10. Frontiers of earth, sea and space. Each problem under a unit describes the principles, applied aspects, if any, simple description of machines or processes or phenomena. There are some activities suggested under many of these. Each unit or problem is well illustrated and some units have further references at the end. There is a list of demonstrations and experiments, a glossary and an index.

Every unit includes the latest advance under the subject, particularly, the last one about the frontiers of space and how they are being explored. The book will be very useful for the teaching of science in high and higher secondary schools.

This is Life : Essays in Modern Biology. JOHNSON, WILLIS H. and STEERE, WILLIAM C. (EDS.). Holt, Rinehart and Winston, New York : 1962. $ 3.95.

The knowledge in advanced fields of biology is increasing rapidly and it is not possible to find within a single text many aspects of modern biology treated to the satisfaction of the interested biology student. *This is Life* is a book which contains a series of chapters dealing with particular aspects of modern biology having great current interest and importance, and written by persons active in that area. The first chapter is on *Photosynthesis*, a process whereby energy is stored, and the second is on *Energy Release and Utilization.* Both these processes involve special structures and the third chapter is a study of these ultrastructures and functions. This includes the very important contribution to modern biology from the field of electron-microscopy. The next chapter considers *Nutrition of Protists*, the unicellular plants and animals.

Chapters 5, 6 and 7 deal with genetics where the most notable advances have been made in the century and which is still an active field today. The viruses and bacteria are dealt with in two of these, and the seventh chapter is on *The Genetic Material and the Concept of the Genes.* The next three chapters deal with *Plant Growth and Plant Hormones*, *Plant Morphogenesis*, and *Animal Morphogenesis*. The last chapter but one is on the *Role of Hybridization in Evolution* and the last is on *The Origin of Life*.

Designed primarly as collateral reading for college students in general biology, it would also be useful to students of a beginner course in botany and zoology, to advanced students as well as to those in other fields of science who want up-to-date information.

Plant Biology Today : Advances and Challenges. JENSON, WILLIAM A. and KAVALJIAN, LEROY G. (EDS.) Wadsworth Publishing Company Inc. Belmont, California : 1963. pp. xi+114.

It is very important to all biologists, whether they are advanced high school students, undergraduates, graduates or teachers, to keep abreast of the most recent developments in botanical research and thinking so that they may be up to date in their facts and concepts. Today the advances in all branches of plant sciences are rapid and one is not able to lay one's hands on all the journals in which they appear. The collection of papers in this book, *Plant Biology Today*, presented at a symposium held by the American Association for the Advancement of Science, deals with current topics and concepts in the field of biology. The knowledge gleaned in these papers will take the reader a step ahead of where he was. The papers deal with five topics : (1) Molecular botany ; (2) The problem of cell development in plants ; (3) Photosynthesis ; (4) Biological clocks ; and (5) The movement of dissolved substances within plants, all of which are currently under intensive investigation. The authors of these papers have by their own investigations, added new facts to the areas they discuss.

Molecular botany, described by James Bonner, is a new exciting field and it is concerned with where enzyme molecules come from, what genes are, and how genes do their work. William A. Jensen deals with the factors that control the development of plant cells in the second paper. In the field of photosynthesis, the subject of the third paper, Bogorod makes it clear that our understanding is not yet complete. Beatrice Sweeney discusses the time-keeping mechanism in plants and animals. Finally Frank, Salisbury presents a field where progress is slow. This is the problem of translocation in plants which has interested biologists for centuries and about which much has been discovered but the complete answer is yet beyond our reach.

This group of articles reflects the growth and development of modern botany.

General Biology. JOHNSON, WILLIS H., LANBENGAYER, RICHARD A. and DELANNEY, LOUIS E. Holt, Rinehart and Winston, New York : revised edition. 1961. $ 7. 95. pp. xiv+655.

The developments in the several fields of biology in recent years are such that new and revised editions of old texts and new books became a necessity. The developments are particularly wide in fields of molecular biology and electron-microscopy. The second edition of *General Biology* shows revisions in the sections dealing with (1) Photosynthesis, (2) Muscle contraction, (3) Nature of the genetic material and gene action, (4) Population genetics, and (5) The origin of life. Two new chapters have been added: a chapter on vertebrate classification and phylogeny, and a chapter on cell function and ultrastructure. The aim in the latter chapter is to associate the processes of cellular respiration with mitochondria on the one hand, and some of the aspects of protein synthesis with ribosomes on the other. An introductory course in biology should include basic facts and principles of biology. These are stated clearly and concisely in this book for students at the college level and for advanced students in high or higher secondary schools.

The concept of organic evolution is a primary integrating principle throughout the text. Emphasis is placed on the cellular nature of the types, nutrition and general metabolism, reproduction and response mechanisms.

S. DORAISWAMI

The World of Physics. BEISER A. (ED.) McGraw Hill Book Co., Inc. New York: 1960. pp. xii+266.

It is well known that science in general and physics in particular have made tremendous progress in the last few centuries, so much so that it is becoming increasingly difficult for a genuine student of science to keep pace with it and its progress. The sciences in school and colleges have not succeeded in meeting this challenge.

There are several ways to tackle this problem. One method is to prepare a well selected group of readings on special topics indicating the growth and development of ideas in physics. This has been attempted admirably in this book. The topics are: falling bodies, rise of science, conservation of energy, entropy, superfluids, special relativity, the discovery of radium, cyclotron, atomic energy, quantum physics, elementary particles, cosmic radiation, fusion power and space exploration. These essays are written by such illustrious scientists as Galileo, Einstein, Maxwell, Barnett, Curie and others as well as by some organizations such as British Information Services and Rand Corporation of U. S. A.

Geology and Earth Science: Source Book. AMERICAN GEOLOGICAL INSTITUTE, Holt, Rinehart and Winston, Inc., New York: 1962. pp. xv+496.

The American Geological Institute has prepared an excellent source book on geology and earth sciences for elementary and secondary schools of the American continent. It deals with minerals, rocks, volcanoes, metamorphism, earthquakes, structural geology, atmospheric science, weathering, water, glaciers, astronomy, origin of the earth, palaeontology, stratigraphy, sedimentation, field trips, topographic maps, geological maps and geological topics for biology, chemistry and physics courses.

Each topic is organized under the following heads : introduction, presentation, facts and ideas, methods and activities, suggested problems and questions, unsolved geological problems ; demonstrations, projects and experiments ; teaching aids ; references for teachers as well as pupils

Though the source book is based on the geology of the American continent, it can be of immense value to teachers and students of geology and earth sciences in India as well.

V. N. WANCHOO

The New Mathematics. ADLER, IRWING. Dennis Dobson, London : 1959. pp. 184.

This book is addressed to the average reader who is curious about the new developments in mathematics. Although the ideas are advanced, the presentation is simple. Anyone who has had high school algebra and geometry will be able to understand and enjoy this book. The central theme around which the book is organized is the expansion of the number system from natural numbers to complex numbers.

A Mathematician Explains. LOGSDON, MAYME I. The University of Chicago Press, Chicago : pp. 189.

By a perusal of this book a student or interested layman would learn what is mathematics, its development and relation to everyday life, and to physical, biological and social sciences. This book is divided into eight chapters : (1) Nature of mathematics ; (2) Arithmetic ; (3) Algebra ; (4) Geometry and trigonometry ; (5) Analytical geometry ; (6) Differential calculus ; (7) Integral calculus ; and (8) Mathematical interpretation of geometrical and physical phenomena ; and (a) Mathematics and life.

This is an eye-opener for the adult who knows no mathematics beyond elementary algebra and geometry but who has a healthy curiosity concerning the science the development of which has made possible the age of the machine.

Principles of Mathematics. ALLENDOERFER, C. B. and OAKLEY, C. O. McGraw Hill Book Co. Inc., New York : 1955, pp. 448.

All other branches of science manage to incorporate modern knowledge into their elementary courses, but mathematicians hesitate to teach their elementary students anything more modern than the work of Descartes and Euler. The author of this book rightly believes that some of the content and much of the spirit of modern mathematics can be incorporated in courses given to undergraduate students. This book is designed to do just that. It is written with the conviction that large parts of the prevailing curricula in mathematics at various levels are obsolete and it is high time that our courses took due advantage of the remarkable advances that have been made during the last century.

The first four chapters are an introduction to abstract mathematical thinking. Chapter 5 begins with an elementary treatment of sets, and then discusses Boolean Algebra and its application to the theory of electric circuits. Chapters 6 to 10 include what the authors believe to be useful and important in the usual courses in college algebra, trigonometry, and analytical geometry. These chapters are not just a condensation of the usual materials but amount to a serious recasting of the basic ideas. The last three chapters deal, within limits, with calculus, statistics and probability. An unusual feature of the book is the set of references at the end of the chapters.

Mathematics : Queen and Servant of Science. BELL, E. T., G. Bell & Sons Ltd., London : 1962, pp. 437.

The author of this book has very successfully tried to suggest that mathematics is vigorously alive and still growing and that it is indispensable for an understanding of some sciences and technologies. He has presented a fascinating account of the various developments in mathematics that have taken place during the last hundred years. The topics dealt with include groups, rings, fields, matrices, theory of numbers, calculus and probability. The book makes a delightful reading. It undoubtedly ranks among the outstanding books on general mathematics.

M. K. SINGHAL

Observatories of Maharaja Sawai Jaisingh

M. F. Soonawala
Department of Physics, University of Jaipur, Jaipur

EARLY eighteenth century saw the beginning of the end of Mughal rule in India and the emergence of other powerful political forces. The country was plunged into a state of political turmoil and internecine strife It was in this complex of events that the lot of Maharaja Jaisingh was cast from A D. 1699 when he took over as ruler of Amber at the age of thirteen to the time of his death in 1743. He was an important figure in the court at Delhi, and upheld his authority and improved his position by consummate diplomacy till he left his kingdom at the time of his death several times bigger than he found it at the beginning of his rule. His many engagements took him to distant parts of the land and there he made the acquaintance of men of learning whose company and talent he much appreciated From early boyhood, he had acquired a passion for astrology, and he had a firm faith in the guiding influence of the stars on human destiny He was a good student of contemporary astronomy, especially, as expounded in the *Surya Siddhanta*, a work held in veneration as the source of all astronomical knowledge However, a lurking suspicion developed in Maharaja Jaisingh's mind about the correctness of the planetary positions as reckoned from the formulae of the *Surya Siddhanta*, and he decided to test this experimentally. He felt that astrological conclusions derived from wrong planetary data would be worthless.

At a time when travel was difficult and the means of the dissemination of knowledge were scanty, the Maharaja's understandable desire to know everything about the astronomical knowledge in the world could only be fulfilled by his sending his personal emissaries to Europe and Eastern and Central Asia to collect information He also invited learned men from these countries to his court where he had already collected a galaxy of Indian talent—learned men even from distant places like Gujarat, Maharashtra and Bengal Some of them were learned in foreign languages like Persian, Arabic and Latin, and had translated foreign books into Sanskrit. Such comparative study convinced Jaisingh of the necessity of erecting an observatory to measure the positions of the heavenly bodies With this end in view he erected the first observatory at Delhi about the year 1725. At the time he was also busy with the ambitious project of a new capital which was completed and occupied in 1728, and which is the city of Jaipur as we know it today. Another observatory was built here about the year 1734.

A frame of reference is necessary before the position of an object can be defined We are familiar with an important frame of reference, namely, the system of longitudes and latitudes on the surface of the earth (Fig 1) R is a reference point on the equator. P is the point whose position is required. SPM is a circle of latitude parallel to the equator and passing through P. NPS is the large circle [illegible] the [illegible] is the pole and P. We [illegible] R [illegible] along the equator through the angle ROQ, the angle of [illegible], and then across the

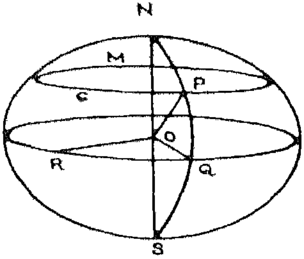


Fig. 1.

circle NPS through the angle QOP, the angle of latitude. We have similar frames of reference in the hemisphere of the heavens above us.

Altitude and Azimuth

The horizontal plane on which we stand extends to the horizon, while vertically overhead is the zenith. In Fig. 2, HOR is the horizon, Z the zenith,

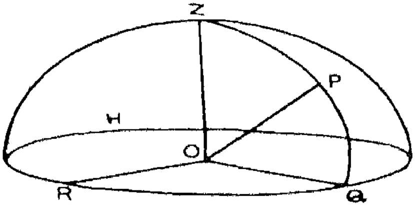


Fig. 2. Illustration

and R a reference point in the horizon, usually the north. The position of a point P in the heavens is given by the angles ROQ, the azimuth, and POQ, the altitude above the horizon. The altitude-azimuth measurements can now-a-days conveniently be taken by a surveyor's theodolite, but the telescope and vernier were unknown to Jaisingh, and so he erected huge masonry instruments to gain precision in measurement. The *Ram Yantra* at Jaipur (Fig. 3) consists of a cylindrical wall, 23 ft. in diameter

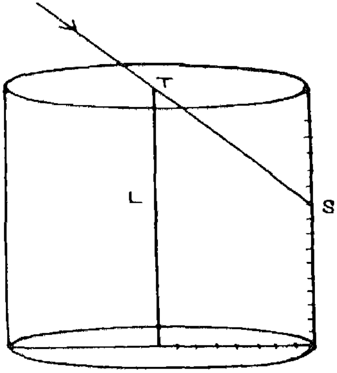


Fig. 3.

and 11' 4" high, with a central pillar, L. The floor and walls are graduated to read angles of altitude and azimuth. The position of the shadows of the top, T, of the pillar cast by the sun gives the altitude and azimuth of the sun. Similar observation can be made of any other heavenly object. The *Digamsa Yantra* is a similar instrument consisting of two cylindrical walls of 27 ft. and 18 ft. diameter with a central pillar. Wires are stretched north-south and east-west on the top of the outer wall, and the shadow of this intersection reads the co-ordinates.

Right Ascension and Declination

The altitude-azimuth system suffers from the serious defect that it depends upon the position of the observer, the zenith and horizon changing from place to place. On the other hand, if we imagine the plane of the equator extended to intersect the heavens in the circle EOR (Fig. 4), and the polar axis to meet the heavens in P, the pole, it would give a fixed reference system. R is the reference point, and the position of A is given by the angles ROQ, the right ascension, and QOA, the declination. If the observer is at P on the surface of the earth (Fig. 5), the plane FH tangent at P is the plane of the horizontal, and POH is the geographical latitude. The north pole will thus be the point at an altitude, FPR, equal to the latitude, angle l, above the horizon in the north direction. The equator will be the circle in the heavens each point of which is 90° away from the pole.

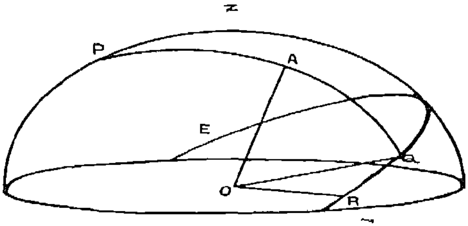


Fig 4

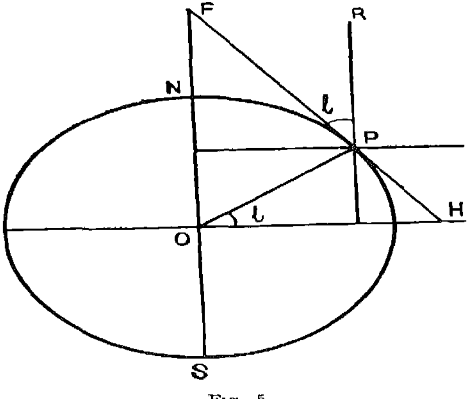


Fig 5

The Equinoctial Sundial

Suppose that QNH is the plane of the horizon at the north pole, and NP is a vertical rod (Fig 6). Sunlight coming from the direction R will cast a shadow NQ of NP As the earth revolves, the shadow will revolve on the horizontal plane with uniform angular velocity once in a day. The position of the shadow will thus give the time of the day. The angle NQP will also give the declination of the sun

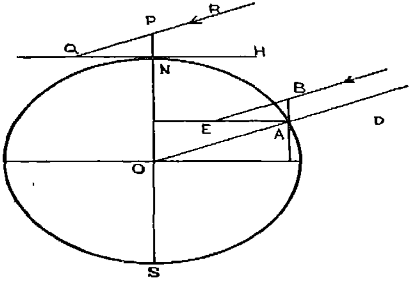


Fig 6

The same will be true of a point A on the surface of the earth. A line AB is taken parallel to the axis of the earth, i.e in the north-south vertical plane and [illegible] CD [illegible] The [illegible] AB [illegible] AB [illegible] plane CAD. As [illegible] AB [illegible]

[illegible] J [illegible] 7 [illegible] of the equatorial circle, [illegible] in diameter.

The [illegible] is the largest [illegible] and occupies the pride of place among the instruments in the observatory. It is a wall shaped as a right angled triangle,

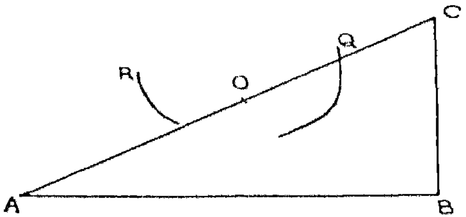


Fig. 7.

ABC (Fig. 7), the hypotenuse AC serving as the *gnomon*. The height BC is about 90 ft. and the hypotenuse, AC, is about 147 ft., so that the angle BAC 26° 56′, the geographical latitude of Jaipur. With a point O on AC as centre, an arc RQ of a circle is drawn at right angles to the plane ABC. This has a radius of about 50 ft. and is shaped as a cylindrical wall some 9 ft. in width. An object like a small thin rod is moved along AC till its shadow falls on the arc RQ. The graduations on the arc read the local time, and the declination of the sun can be read off from graduations on the [illegible]. Similar measurements can be carried out for any other heavenly object. It was mostly with this instrument that most of the observations were carried out by Maharaja Jaisingh. The object he had in view of attaining high accuracy in the measurements of angles by using larger circles was partly offset by the indistinctness of the shadow on the arc.

The *Jai Prakash* was another of his favourite instruments. It is a concave hemispherical bowl, 18 ft. in diameter, sunk into the ground, and carrying a map of the heavens by marking of circles of equator, tropics, hour angles, altitude-azimuth circles, etc. The shadow of the centre of the sphere would show the position of the sun.

Another instrument serving a similar purpose is the *astrolabe*, a very favourite companion of the astronomers of the middle ages. In principle, it is stereographic projection (Fig. 8). A point on

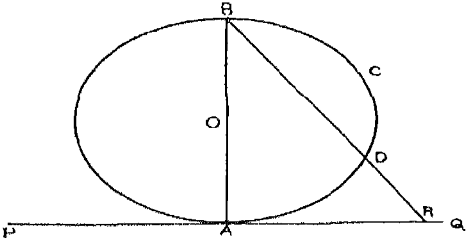


Fig. 8

a sphere ABC is represented on the plane PAQ by the point R in which PAQ is cut by the line BDR drawn from the pole B of the sphere and the point D on it. Such mappings of the astronomical positions as of the equator, tropics, hour angles, etc , on plane surfaces were called *astrolabes*, which were often adorned by all the artistry of good craftsmen. The *astrolabe* can also be used as a mechanical calculator for finding the time of sunrise or sunset, the length of the day, etc , and it was in this manner that it was mainly used by Maharaja Jaisingh. He called it the *Yantra Raj*. The Jaipur instrument is a brass circle, 7 ft in diameter, hung by hooks from a large wood and masonry support

There are other instruments, but the preceding list will suffice to bring out the salient features of the Jaisingh observatories, often aptly named the Jantar Mantars. From the wealth of data acquired from these astronomical measurements, Maharaja Jaisingh constructed the astronomical tables, or star catalogues modelled after the older ones of Ulugh Beg and Ptolemy This he dedicated to the then Emperor, Muhammad Shah, and is therefore called the *Zij-i-Muhammadshai* The name of Maharaja Sawai Jaisingh is better remembered by this immense monument, his catholicity of outlook, and a strangely modern scientific spirit of enquiry, than by the military campaigns, political diplomacy, or cunning kingcraft, that many times fill the pages of history. He lived and died a scholar among princes and a prince among scholars.

Photosynthesis

A. C. Jain
Department of Chemistry, University of Delhi, Delhi

PHOTOSYNTHESIS is a process by which oxygen and an astonishingly large variety of organic compounds, both simple and complex, are synthesized from carbon dioxide, water and a handful of simple inorganic salts in the presence of sunlight. This synthesis of vital importance to life on this planet is carried out only by living cells restricted to green plants and such bacteria as possess special types of pigments. The purple and brown bacteria have bacteriochlorophyll and during the photosynthesis by these organisms no oxygen is evolved as a by-product. Animals including human beings lack this pigment and are therefore incapable of photosynthesizing, and indeed they have to depend for their food either directly or indirectly on plants which alone can synthesize food for themselves. All attempts to achieve this reaction in the laboratory without the help of living plant cells have met with failure. Hence, not only the basic ingredients mentioned in the definition but some enzymic catalysts present in the living cells are necessary for bringing about photosynthesis. Though the organic compounds formed belong to different structural patterns, carbohydrates seem to be first formed in photosynthesis and the general equation for this type of product can be written as follows:

$$n\,CO_2 + n\,H_2O \underset{\text{Respiration}}{\overset{\substack{h\nu,\ \text{chlorophyll,} \\ \text{inorganic salts} \\ \text{and enzymes}}}{\rightleftharpoons}} (CH_2O)n + nO_2$$

It may be noted that the above equation is the reverse of another important reaction taking place in living cells called respiration. This basic reversible reaction had been recognized by J. Priestley as early as 1772. During the next 40 years, all the basic ingredients of photosynthesis had been understood, but the mechanism of photosynthesis remained only a matter of speculation until the beginnings of the present century. The first significant observation in the understanding of the mechanism of photosynthesis was made by Blackman in 1905 who showed that the whole process of photosynthesis is not dependent on light; a part is a dark reaction also. Now it is known that photosynthesis consists of two parts, one is concerned with photophosphorylation and photolytic splitting of water which require light and the pigment for their accomplishment, and the other is the reduction of carbon dioxide and subsequent reactions to form various organic compounds which though dependent on the products of the first reaction can take place in the dark when the earlier steps have been achieved. The mechanism of the first part is only partially known but the key information in this regard was first provided independently by Hill, Van Niel and by Ruben and Kamen in about 1941 and more recently in 1960 by Arnon. The dark reaction has been more completely worked out only during the last few years at Berkeley, California, by Melvin Calvin who was awarded the Nobel Prize in Chemistry in 1961

Thus photosynthesis as understood today involves several steps First, the light energy is absorbed by chlorophyll and related pigments and is thereby converted into high chemical potential energy of some compounds. Secondly, these compounds react with water and produce oxygen and good reducing agents as well as other cofactors (viz , adenosine triphosphate, ATP) cotaining high chemical potential energy. Finally these reducing and energetic cofactors react with carbon dioxide and other inorganic compounds to produce a large variety of organic compounds We shall discuss these steps one by one

The Role of Pigment and Light

Chlorophyll, the green pigment in plants is most suited for the absorption of sunlight. The green plants contain a mixture of two chlorophylls, *a* and *b*, present in a constant ratio of 2.9 1 Two other chlorophylls, *c* and *d*, are present in red and brown algae, diatoms and dinoflagellates while the chlorophyll present in the cells of purple and brown bacteria is called bacteriochlorophyll. These are all macrocyclic pigments containing 18 atoms in the ring and differ from one another in minute details, the structure of chlorophyll *a* is shown in Fig 1.

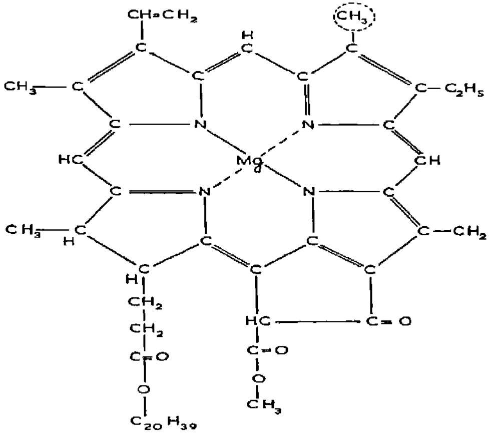
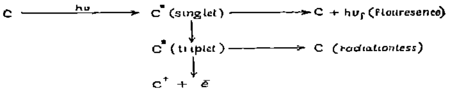


Fig 1 Structure of Chlorophyll *a*

Chlorophyll in living cells absorbs light in the region of 675-680 mμ and as a result of absorption it gets converted into a singlet excited state. This singlet can either lose this energy by emitting light (flourescence) or be converted into a triplet state The former reaction takes place when there is isolated chlorophyll in solution but it is the latter reaction which takes place in living cells. The triplet state is characterised by instability and is capable of giving chemically active electrons Thus light energy is converted into chemical potential How the structure of chlorophyll is modified is not yet clear. One opinion which is nearer truth is that of Warburg, it considers that the five membered isocyclic ring (E) opens up during this conversion.



(C stands for chlorophyll)

Photolysis of Water and Photophosphorylation in Green Plants

Hill and Scarisbrick (1940) were the first to show by using isolated chloroplasts (chlorophyll containing particles) from *Stellaria media* and *Lamium album* that the photochemical production of oxygen required the presence, not of carbon dioxide, but of a suitable hydrogen acceptor and that when this was added to the pre-

[illegible] produced in [illegible] comparable work that [illegible] maximum rate of photosynthesis [illegible] in the living plant. Among the [illegible] reagents used [illegible] oxygen [illegible] found to have the greatest [illegible] potential in the chloroplast reaction.

In 1941, Ruben and Kamen clearly demonstrated that the evolved oxygen during photosynthesis in green plants result from the decomposition of water. This was proved by experiments in which plants were kept in water enriched with heavy oxygen $H_2{}^{18}O$, when the oxygen evolved proved to be isotopically labelled.

$$CO_2 + 2H_2{}^{18}O \rightarrow (HCHO) + H_2O + {}^{18}O_2$$

It is however only in 1954 that the actual photolysis and other light dependent reactions were made clear by Arnon and his collaborators at the University of California. By careful work, they were able to isolate chloroplasts from spinach leaves so that the isolated chloroplasts preserved the ability of carrying out complete photosynthesis (cf. Hill's isolated chloroplasts were not able to assimilate carbon dioxide). They separated the light and dark phases of photosynthesis in chloroplasts. The light reaction in the absence of carbon dioxide was found to convert a mixture of adenosine diphosphate (ADP), inorganic phosphate and TPN^+ (triphosphopyridine nucleotide) into adenosine triphosphate (ATP), and TPNH with the simultaneous evolution of oxygen gas. These products were later found to assimilate carbon dioxide in the dark and to produce the same carbohydrates that the intact plant manufactures. *Thus the formation of ATP and TPNH were shown to be the major light-dependent reactions.*

In later experiments it was shown that ATP is manufactured in major amount by a cyclic process called *cyclic photophosphorylation* and the process was found to be accelerated if cofactors like flavin mononucleotide (FMN), ascorbic acid, vitamin K or similar oxido-reductive systems that could initiate electron transfer were added. The process is illustrated in Fig. 2 which shows that the electron is first captured by vitamin K or another cofactor and then moves to the cytochrome enzyme system losing energy to a phosphorylating enzyme system which employs the energy to couple a phosphate group on the ADP. As the electron passes back to chlorophyll from cytochromes, it again gives up energy to form another molecule of ATP. The chlorophyll acquires a positive charge when it ejects the electron and is thus able to pull the returning electron from the cytochromes. No outside electron donor is used and the system functions as a self-contained cyclic mechanism.

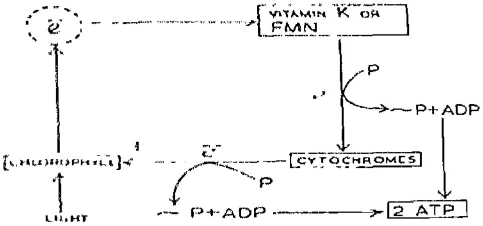


Fig. 2. Cyclic photophosphorylation

Non-cyclic photophosphorylation has been found to be taking place in isolated chloroplasts. However, only a part of light energy absorbed by chlorophyll is used for the formation of ATP; the remainder is used for the formation of TPNH. It is this process which involves photolysis of water. The overall equation may be written as follows:

$$2\,TPN^+ + 2\,ADP + 2H_2O + 2H_3PO_4 \longrightarrow 2\,TPNH + O_2 + 2ATP$$

The reaction may be simulated to the electrolysis of water. Water dissociates partly to H^+ and OH^- ions. The proton accepts an electron pair from light energy and becomes hydride ion which reduces TPN to TPNH. On the other hand, hydroxyl anion loses an electron to cytochrome and itself becomes a hydroxyl radical, two such hydroxyl radicals combine to yield water and oxygen. The cytochromes in turn pass on electrons to chlorophyll and in this process raise phosphate anion to couple on to ADP. Thus the non-cyclic photophosphorylation differs from the cyclic one in that the electron expelled does not return to chlorophyll but is removed from the cyclic pathway by TPN^+. The non-cyclic photophosphorylation is shown in Fig. 3.

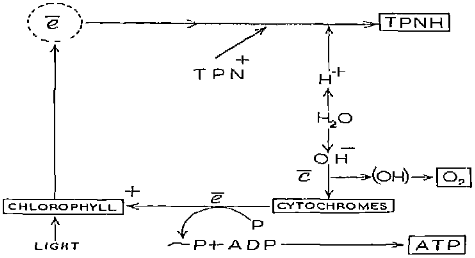


Fig. 3 Non-cyclic photophosphorylation in green plants

Light Dependent Reactions in Bacteria (Formation of ATP and TPNH)

As early as 1880, Engelmann at the University of Utrecht found that purple bacteria which metabolise sulphur compounds perform a type of photosynthesis apparently without giving off oxygen. But it took about sixty years to establish this fact. Only in 1941 Van Niel wrote the following photosynthetic equations for photosynthetic bacteria

$$2\,CO_2 + 4H_2O + H_2S \xrightarrow{hv} 2(CH_2O) + 2H_2O + H_2SO_4$$

$$CO_2 + 2H_2O + 2H_2SO_3 \xrightarrow{hv} (CH_2O) + 2H_2SO_4 + H_2O$$

This emphasises the fact that evolution of oxygen is not essentially a photosynthetic reaction.

Working on the red sulphur bacterium *Chromatium*, Arnon has recently established that both cyclic and non-cyclic photophosphorylations occur in this bacterium just as in chloroplasts. Most of ATP is made by the former process (see Fig. 2). Non-cyclic electron-transport mechanism in this bacterium involves the transfer of electrons from thiosulphate and succinate anions. Energized in chlorophyll, they can reduce pyridine nucleotide, join nitrogen to make ammonia or make hydrogen gas; ATP is also formed. This is shown in Fig. 4.

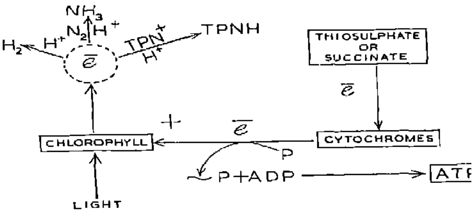


Fig. 4 Non-cyclic electron transfer mechanism in the bacterium *Chromatium*

Dark Reaction: Carbon Reduction Cycle of Photosynthesis

The organic compounds formed from carbon dioxide which is the only source of carbon are of different types such as carbohydrates, amino acids, proteins, fats, [illegible] which are [illegible] chemical potential, are regarded as photosynthetic, e.g., carbohydrates and amino acids. And others, which are formed by degradation of the [illegible] compounds and which are stable are considered non-photosynthetic; they are also called metabolic products. The latter are formed freely in animal cells.

Attempts have been made over a great number of years to discover the sequence of steps in the reduction of carbon dioxide and many theories have been advanced, but it is only during the last decade that any convincing evidence has come. The recent work has been made possible largely through the availability of the radioactive isotope of carbon, i.e., ^{14}C and by the discovery of new microtechniques of identification such as radiochromatography.

The experiment to show the steps in carbon reduction was carried out by Calvin as follows. The green unicellular plant, *Chlorella pyrenoidosa* was suspended in water containing necessary inorganic ions (nitrate, phosphate, etc.) and aerated with a stream of ordinary carbon dioxide gas and simultaneously illuminated. The photosynthetic plant takes up carbon dioxide from the solution where it is in equilibrium with bicarbonate ions and thus synthesized various organic compounds. Now, suddenly a solution of radioactive bicarbonate was introduced into the algal suspension. As the plant is unable to distinguish between ^{12}C and ^{14}C, some ^{14}C got rapidly incorporated into a large number of different substances formed during the photosynthesis. This exposure to radioactivity was done for period varying from a fraction of a second to a few minutes in different experiments to arrest the compounds formed at different stages. The photosynthesis was arrested by suspending the plant cell in alcohol when the pattern of ^{14}C labelling got arrested. Finally the dead plant was analysed for radioactive compounds formed.

The formation of a number of compounds makes the identification difficult. But it was successfully accomplished by Calvin using radiochromatography. First two-dimensional paper chromatography was carried out and the chromatogram placed in contact with a sheet of X-ray film when black spots on the film appeared corresponding to each radioactive compound on the paper. Identification of these spots was done in a number of ways: (1) by comparing the position of the spots with those of the known compounds under identical conditions, (2) by eluting the spot and identifying the compound by its physical or chemical properties, and (3) by co-chromatography with the authentic sample.

In the experiment of the briefest illumination (0.1 sec.) Calvin identified 3-phosphoglyceric acid (3-PGA) as the first stable product labelled in the carbon of the carboxyl group. This suggested that the carbon dioxide acceptor is a C_2 unit which is continuously regenerated during photosynthesis. However, no evidence to support this hypothesis could be obtained. In a quantitative experiment it was found that one mole of carbon dioxide gave two moles of 3-PGA each with 3 carbon atoms and it was concluded that a 5-carbon acceptor of some kind was involved. In a study of the effect of external variables (temperature, light, partial pressure of carbon dioxide and oxygen) Calvin found that the diphosphate of a pentose sugar ribulose (RDP) which was also identified as another product of photosynthesis and 3 PGA are related in a reciprocal manner. Those factors which suppress the formation of RDP, correspondingly increase the production of 3-PGA and *vice versa*. It was thus proved that RDP is the first acceptor of carbon dioxide and it gets converted into two molecules of 3-PGA through an intermediate as shown in Fig. 5.

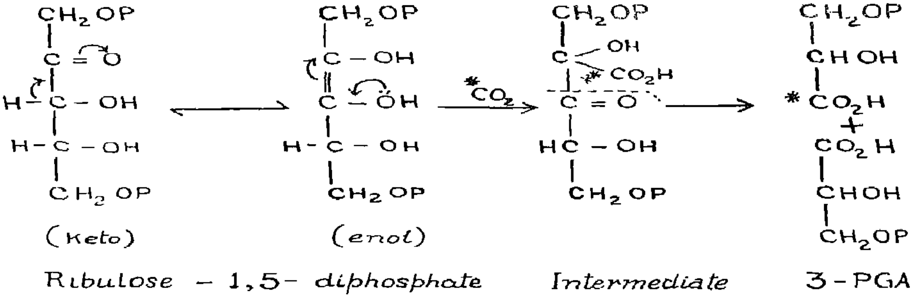


Fig. 5

The carboxylation reaction is a curious one and seems to be possible only with the help of a special enzyme. The decomposition reaction is simple to follow because the intermediate is a β-keto acid and it can undergo the desired reaction. This is the first of a series of reactions that lead back eventually to the regeneration of ribulose diphosphate.

Further it was found that in the carbon cycle of photosynthesis, five moles of 3-phosphoglyceric acid are required to give 3 moles of RDP. Hence it was concluded that out of 6 moles of PGA formed from 3 moles of RDP and 3 moles of carbon dioxide, five moles of PGA are used in the carbon cycle and the sixth mole gives products outside the cycle.

Other radioactive compounds detected in short exposure experiments were found to be dihydroxyacetone monophosphate (DAMP), glucose 6-phosphate and fructose 6-monophosphate. Obviously two moles of 3-PGA are first converted into two triose units which then couple to give a hexose unit. In agreement with this idea, labelling in the 3 and 4 carbon atoms of hexose units were found to be twice as much as in the case of others. TPNH

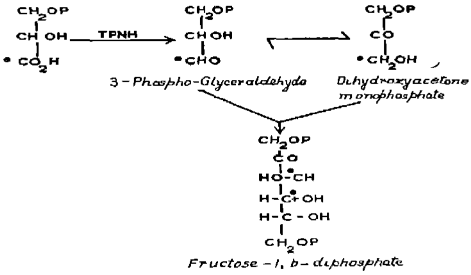
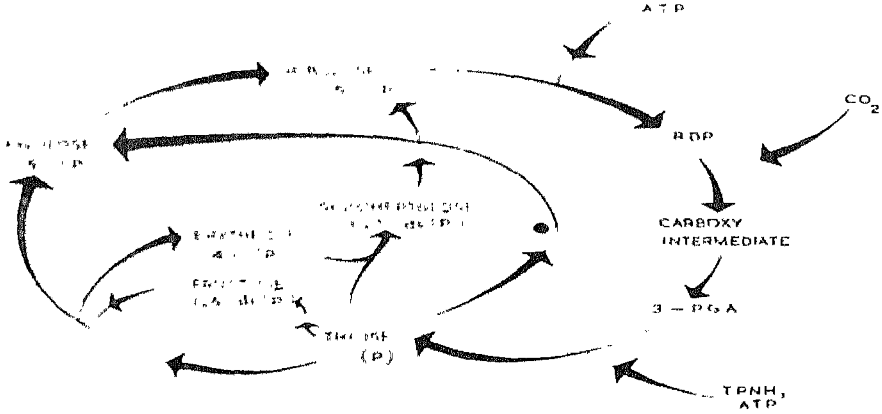


Fig. 6.



[illegible]

[illegible] about the conversion of 3-PGA to a triose unit and the condensation of two C_3 units is then as shown in Fig. 6. In addition to the two common D-hexose phosphate and one pentose phosphate, a few other D-sugars were also identified in the form of phosphates as early products in photosynthesis, they are 7-phosphate of the 2-ketoheptose sedoheptulose, 4-phosphate of tetrose erythrose and xylulose-5-phosphate. The above tetrose and pentose units probably arise by the condensation of one triose unit and one hexose unit. The tetrose unit condenses with a triose unit to give sedoheptulose which in turn gives rise to two moles of pentose units, by condensation with a triose unit. In this way the formation of 3 moles of RDP from 5 moles of 3-PGA was accounted for, and the carbon cycle established. Thus for a complete turn of the cycle, the carboxylation reaction with atmospheric carbon dioxide has to occur three times and the whole cycle requires 6 moles of TPNH and 9 moles of ATP. As the products isolated were all phosphorylated, the role of ATP is defined to bring about the phosphorylation, this seems to be necessary to activate the molecule. The whole carbon cycle is shown in Fig. 7.

Other known metabolic pathways leading from the sixth mole of 3-PGA, give rise first to phospho-enolpyruvate which then may undergo further transformations including the following: (1) it may be carboxylated and transaminated to give aspartic acid; (2) it may be dephosphorylated and transaminated to give alanine; and (3) it may be carboxylated and reduced to give malic acid. All these compounds were isolated as labelled ones in the above experiments as shown in Fig. 8.

Conclusion

Thus it is clear that in nature the basic synthetic apparatus for carbon compounds is provided by green plants and certain micro-organisms. Indeed a continuous chemical industry is going on in nature on a tremendous scale During photosynthesis, oxygen gas comes from water and carbon dioxide undergoes reduction to give rise to a variety of compounds The immediate acceptor of carbon dioxide is a pentose sugar and the carbon cycle involves only a few other carbohydrates (fructose, erythrose, xylulose and sedoheptulose). These are the real precursors of other carbohydrates and phosphoglyceric acid formed in the cycle acts as the precursor of other types of compounds It may be remarked that the greatest contribution to chemistry during recent years has been in the field of understanding how the organic compounds are evolved in nature

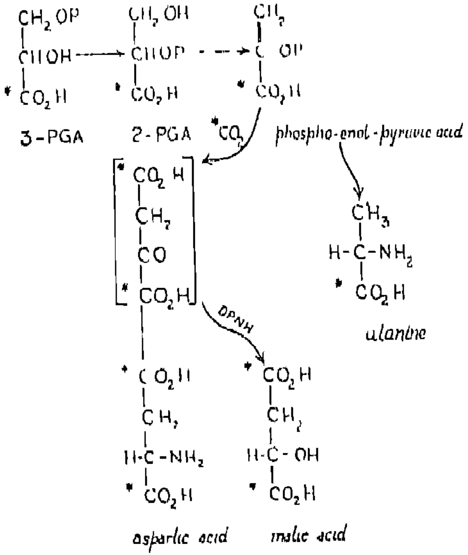


Fig 8. Some photosynthetic products other than carbohydrates

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Darwinism Through Hundred Years*

P. K. Menon
Formerly Professor of Zoology,
Presidency College, Madras

IT was an uncommon coincidence in the history of science that two tireless naturalists, Darwin and Wallace, should have been writing down their views on the problem of the origin of varieties and species in nature at the same time, in different places, and unknown to each other, and should have come to nearly identical conclusions Wallace was then in the Malay Archipelago. His essay, 'On the Tendency of Varieties to Depart Indefinitely from the Original Type' was sent to Darwin for perusal and subsequent communication to Lyell for publication, if found fit. Darwin on the other hand, at the persistent insistence of Lyell and Hooker, was writing down his theory of Natural Selection which he had conceived clearly even in 1839, on the basis of his laborious collection and studies particularly during his 5-year voyage on the *Beagle*. This was early in the summer of 1858. The receipt of Wallace's essay created a crisis in Darwin's life. But true to his character and generosity his first reaction was to hold back his own work and allow Wallace's to be published. Lyell and Hooker had to use all their powers of persuasion to make Darwin consent to have an abstract of his own manuscript published along with Wallace's essay in the *Journal of the Proceedings of the Linnaean Society*. This was the epoch-making Darwin-Wallace essay of 1859 Lyell and Hooker did not stop at that. They pressed Darwin to prepare a volume on his theory. At the end of more than a year of hard work the volume was published in 1859 under the title, 'On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life' (*The Origin of Species* or *The Origin*, for short.)

It is implied in the title itself that Natural Selection is not Evolution. The two are different facts of nature According to Darwin - and it is generally accepted - the former is the means by which the latter is brought about. This causational relation between the two is the essence of the theory of Darwin, what has come to be known as Darwinism. Though the credit for putting the concept of evolution on a scientific basis of facts of nature is mainly Darwin's, the concept is much older than Darwin. Even the Greeks had realized that change was the essence of existence. Anaximander had thought of man as related to animals. But the idea was then vague. Even the eminent pre-Darwinian evolutionists like Erasmus Darwin, Buffon and Lamarck were not free from creationist ideas.

Darwin's achievement was not the collection of the enormous data to support his theory. Anybody with patience and industry could have done that Nor was

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the principle of Natural Selection altogether his own. His inspiration for it was from Malthus' Essay on Population. His real achievement was, as Carter says (1957), that from such simple and common premises he 'produced the fundamental and to his contemporaries novel results of his proof of the truth of evolution and his theory of its causation'. Though fundamental and profound, the whole theory was so simple as to get easy acceptance by those who could see nature objectively and with an open mind. To those who accepted it, it provided a unifying concept in the light of which organisms ceased to be isolated entities and came to be understood as part of the single flow of life continually changing with the changing world. As Earl Russell put it (1951), Darwin 'substituted general laws based on evidence for fairy-tales embodying a fantasy of wish fulfilment'. Darwin gave biology an intelligible background and made it logically comprehensible.

The early reaction to Darwinism was from two sources, from the general public and the biologists. There was hence sentimental opposition from a section of the public to evolution and its method as expounded in Darwinism. Human nature is generally inclined to base opinions particularly on life and problems of life on hopes and flattering beliefs rather than on factual evidence. So it is no wonder that the simple forthright interpretation of Darwin in terms of fortuitous events leading to order and seeming purpose through natural selection, was unpalatable to them as it conflicted with their ideas of the Creator and Design. The climax of this was reached at the Oxford meeting in 1860 at which Bishop Wilberforce deliberately attempted to 'smash Darwin' and ended up in being smashed by Huxley.

The more important point was the reaction of the biologists to Darwin. Generally the biologists of the day reacted favourably. But it should not be imagined that all the biologists acknowledged the theory without adverse criticism. Some criticism was based on orthodoxy and sentiment. But there were many points of criticism which were valid and reflected real weaknesses of Darwinism. The following few among many are noteworthy.

1. Though Darwin had observed variations and realized their basic importance to evolution he was fully ignorant of their causes or nature. Darwin himself admitted and deplored it. He considered the so called acquired variations also as important to evolution. He even went to the extent of suggesting a mechanism of inheritance in the form of his theory of 'pangenesis'. It however never deserved and never got any acceptance. It was exactly this gap in Darwinism that was filled by modern genetics.
2. Evolutionary change involves coordinated changes. For example, an increase in the size of the body will need many correlated changes if the animal is to be efficient. Darwin almost overlooked this fact in his thesis. Perhaps he did not consider it as a serious difficulty to his view of evolution by accumulation of small variations. However, such correlated changes are not now difficult to understand in terms of polygenes and pleiotropism (Dobzhansky, 1951) and allometric changes (Huxley, 1932).
3. Those, whose biology was based on Naturphilosophie, did not easily accept Darwinism as it was not an answer to their quest for the Absolu-

te idea or the Divine plan of Nature or the conception of the archetype. To them law was something immutable, to Darwin it was a deduction from known facts

4 Many other criticisms which then looked like real difficulties have lost their point in the light of the new knowledge One such relates to complex structures like the vertebrate eye. The question was, could they have been of any use in the initial stages when they could have hardly functioned? If not how could they have been selected? A study of the light-perceiving organs in the animal world makes it readily clear that even the simplest of them like the eye spots of the green flagellates have been functionally efficient at their level. So evolution has been not only in structure but also in function This removes the seemingly insuperable difficulty in accepting the complex organs as the products of Natural Selection

During the forty-one years of the 19th century after the publication of *The Origin*, Darwinism came to be almost fully accepted, thanks partly to the championship of Thomas Huxley in England and of Haeckel in Germany. Huxley was a competent biologist himself and an effective writer and speaker to boot So he had no difficulty in winning the battle for Darwin. Haeckel too had accepted Darwinism. But his version of the theory was tinged with Naturphilosophie. His chief contribution was the Theory of Recapitulation which was almost Naturphilosophic with the commonness of descent instead of the archetype. It was quite contrary to Von Baer's laws of ontogenesis. In the latter years of the 19th century, Darwinism remained particularly unchanged except for the rejection of the Lamarckism part of it along with Lamarckism in general as a consequence of the Weismannian theory of the isolatedness of the *gonad* from the soma so as to leave the former unaffected by change of the latter. In this period there was little progress in evolutionary biology But there was an enormous output of morphological work in the several branches of biology. Much of it was by way of attempting to prove evolution and Natural Selection. It was only towards the end of the century that experimental embryology began to change the outlook of biologists a little.

The present century began with evolution well established as a fact except for those who did not want to accept it. The almost total acceptance of evolution restricted the field of discussion and controversy to the means by which evolution took place By the close of the 19th century, Darwinism too had been accepted as the means of evolutionary change. The idea had penetrated all aspects of human thought Even the reactionaries, the warmongers and the laissez-faire economists had found support in Darwinism though that was the last thing that Darwin could have wanted

The history of Darwinism from the beginning of this century is a good example of how a comprehensive scientific concept undergoes change and refinement by impact of growing and more precise knowledge. Newly discovered facts often seem to contradict an earlier theory, but as often, eventually conform to it. So too discoveries in different fields may point to the same conclusion from different angles ultimately resulting in synthesis. All these are eminently exemplified in Darwinism in the 20th century The most important factor that affected Darwinism in the last 60 years was the rapid growth of the science of heredity, genetics. This supplied the missing parts of the structure first erected by Darwin (Fisher, 1930). The bases of modern genetics were the laws of Mendel published in the latter half of the 19th century. They were far ahead of the times and remained unknown till they were rediscovered in the beginning of this century. The particulate nature of inheritance discovered by Mendel had revolutionary effects on the understanding of evolutionary problems.

Darwin had assumed the hereditary characters of the parents to blend in the progeny like water and milk. That would result in a levelling off of variations to uniformity in the members of a population and would defeat selection. This was the most serious difficulty in Darwinism and it was obviated by Mendelian particulate inheritance. As shown by Fisher (1930), if inheritance had not been particulate, evolution as we know it would not have been possible. Mendelian heredity provided *a mechanism for both inheritance* and variation, the conservative and the progressive aspects of evolution.

At this stage it may look strange that the first result of the Mendelian studies was to create a degree of disbelief in natural selection. De Vries's work on the evening primrose was published in 1901. He had noticed that many new forms suddenly appeared among his plants and bred true. He called such changes mutations and contended that evolution took place at least partly through such abrupt changes without involving the natural selection of small variations. Natural selection acted in such cases only after the origin of the new form conserving or eliminating it. Bateson also held similar views. This gave a new importance to the distinction between the continuous and the discontinuous variations in regard to the process of evolutionary change. Darwin had attached little importance to the discontinuous variations. That accounts for the temporary loss of faith in natural selection. Mendelism seemed to conform to the views of these doubters of natural selection because of the apparent possibility of the large changes of De Vries and Bateson being inherited as Mendelian units. It was soon found, however, that many kinds of characters of organisms were inherited in Mendelian manner. Meanwhile Morgan and others discovered the cytological basis of Mendelian inheritance, in terms of chromosomes and genes and their behaviour in reproduction. It will be going too far from the topic to consider the progress of genetics in the last sixty years. Suffice it to say that in this period genetics became in itself an exact body of science and illumined many dark corners in biological knowledge, particularly in evolutionary studies. The understanding of genetic variations, mutations in the wide sense, their nature and frequency and even some of their causes (Muller 1927), the problems of population genetics, the conceptions of the genotype and the phenotype clarified and strengthened natural selection steadily and surely. But as mentioned earlier the first impact of genetical knowledge on Darwinism had the unexpected result of many giving up the theory. It is not difficult to understand this either. Darwinism involved the gradual accumulation of small graded changes by natural selection. This was the indication of palaeontological studies too. On the other hand the early genetics dealt with changes that could be readily and easily noticed and so were of the discontinuous type. It seemed impossible to the leading biologists of the day that the observed evolutionary changes could be the result of selection of such genetic changes. This led to violent clashes in the biological world in the first two decades of the century. Bateson took an extreme view and declared that Darwinism as theory had collapsed He went to the extent of reverting to a sort of preformationism in evolution involving the progressive expression in organisms of the potentialities that had existed from the beginning of evolution. Many took up similar though less extreme views.

The real point at that time was whether the small variations on which natural selection was said to act were also Mendelism. This was not discussed then as probably it could not have been in that state of genetical knowledge. The discussion was concentrated on whether the continuous or the discontinuous variations were the raw materials of evolution. This was a wrong question to ask and largely accounts for the biological stalemate of the time. This was resolved by further genetical studies in the recent decades. Two important advances in the field of genetics contributed to this. One was the new outlook on the genotype, and the other the new approach to studies of natural populations and their genetics. These also threw revealing light on the operation of natural selection in the recent decades of the century.

In the earlier decades of the century a genotype was considered more or less as an aggregate of genes with a degree of independence of action. Recent decades brought the realization that the genes of a genotype constitute an intricately interacting system and that the phenotype is the product of such combined action of the genotype and the environment. A mutation in such a system will have its effect much modified by the other genes present and also by other mutations. Since individuals in a population vary in their genotype the effect of a mutation also will vary correspondingly. Further, when many genes influence a character and any one gene may influence many characters the phenotypic expressions of the individuals may show the gradation observed in the palaeontological studies, and envisaged by the theory of natural selection. It is true that a mutation is inherited as a unit, all or none. But its expression in the individual depends on the genotype and the environment. This explains the varying effects of mutations on individuals. But it should not be forgotten that there are many known instances of mutations with phenotypic effects very distinctive and inherited like the characters of Mendel's peas. The pigmentation in what is known as industrial melanism is one such. They are comparatively rare however. Normally in nature the differences are those based on many genes and varying in degree. This understanding brought about a reconciliation between the geneticists and the selectionists. The objection of Bateson and others thus disappeared. It also became clear that selection was not directly of the genotype but through the phenotype. Selection of a particular phenotype meant the selection of the genotype that produced it. It is largely a case of selection of the favourable recombinations of genes. It also allows for a margin of phenotypic adjustment to environmental variations In the course of generations the more suitable gene combinations become more numerous in the population. In this process the favourable mutations that may arise may be incorporated into the genotype. The first effect of any mutation is usually a discordance as it is something new in a harmonious system. But subsequent selection will integrate it into the genotype if useful or eliminate it if harmful. Either way the harmony is restored. That implies that a mutation has to undergo a probation before it is accepted as a full member of the genotype with suitable modification of its action by the rest of the genotype (Huxley 1942). Natural selection in this sense is the differential survival of the favourable genetic variant.

The slowness of selection makes it impossible of observation. But something like it has been observed in recent times. Germs are known to develop resistance to antibiotics rather quickly. This is obviously a case of selection of the favourable genotype at the expense of the others, in the presence of a new factor in the growth medium, the antibiotic (Demerc, 1950). Varieties of *Drosophila* kept in equal numbers in set environments have been found to undergo selective survival in relation to the environment. Green mantis was found to survive largely on green grass but mostly eaten by birds on brown grass. On the other hand brown mantis survived on brown grass but were decimated on green grass. The selective advantage of harmonising colour is thus demonstrated. These may not be true pictures of selection in nature. But their value is significant.

The new knowledge of selection in genetical terms has in its turn clarified the changes within a species and between species. That brings us to population studies, another sphere of advance in recent times. The world of biology owes tremendously in this connection to the brilliant mathematical analyses of the genetics of population and selection by R.A. Fisher (1930), J.B.S. Haldane (1932) and Sewell Wright (1942). To this must be added the names of Dobzhansky, E.B. Ford and E. Mayer. Their expositions of the interactions of selection, mutation and other factors of evolution in populations have made possible the synthesis of varied observations and experimental results into a coherent thesis (Simpson, 1942). A population is now understood as an evolving unit. It is the population that evolves not the individual.

In that sense a population is a genetic system in which the individuals interchange genes by the sexual process. Such a population with a common gene pool which the individuals share in and contribute to is called a Mendelian population. A Mendelian population approach over large geographical areas tends to differentiate into local sections in accordance with the local environmental differences. Such differentiation leads a population to split into varieties or subspecies. They are then Mendelian populations of a lower order. They have chances of fusion at their margins with exchange of genes. This kind of splitting and fusing are common in populations under selection. If the differentiation continues long enough to make fusion difficult or impossible then new species result. The Hardy-Weinberg law, or the binomial square law, representing equlibrium in a population breeding at random is the basis of genetics of population and selection in population. Its implications are too complicated to be dealt with here. The subtle ways of the opertion of natural selection and evolution by selection are now satisfactorily understood. The obvious fact that some individuals in a population leave more progeny than the others makes natural selection inevitable. This ability to leave more progeny than others in a particular environmental setting is the real fitness in the Darwinian sense. The well-known expressions 'struggle for existence' and 'the survival of the fittest' were used by Darwin in a metaphorical sense. 'I should promise', said Darwin in the *Origin*, 'that I use this term in a large and metaphorical sense including success in leaving progeny. The convenient interpretation of the expressions by some persons is quite unwarranted. Reproductive success based on advantageous genotype is therefore, the essence of evolutionary change. A population will gradually change in the direction of the genotype which leaves more progeny in successive generations. This is how natural selection directs evolution using the 'random' genetical variations as the raw material. This is the most significant contribution of the present century to the understanding of Darwinism

This article is an attempt to trace the history of the Darwinian theory of evolution by Natural Selection, during the hundred years since Darwin and Wallace propounded it. In the period the theory has been knocked into a cocked hat. But the core of it has stood the test of time Generally it is adequate to explain the process of evolution. But there are still many problems of evolution, particularly in regard to the large evolutionary changes, which it is not adequate to explain Most of the biologists agree with Darwin that varieties are incipient species and differ only in the greater degree of divergence, to a degree that makes natural interbreeding difficult or impossible. Some authorities like Goldschmidt (1940), do not agree with this view. He postulates radical mutations which he calls 'systemic mutations' to produce species differences. How such radical changes in individuals with integrated genotype can leave them viable is difficult to see.

There are others who are not convinced of the effectiveness of selection in all the known evolutionary changes. Many bring in the Lamarckian factor in some sort of way. One of the latest is C.H. Waddington (1957). In terms of genetic assimilation, epigenetic landscape and canalized development, he suggests a casual relationship between an effect caused by the environment and the production and selection of appropriate mutations. A phenotypic alteration within the normal range of the expression of a genotype is understandable. There is no difficulty to see how such a change may help the organism to tide over a reasonable period during which the genotype may be harmonized to the new condition by selection of appropriate mutations. The difficulty is to understand how enough and suitable mutations arise at the right time. One possibility is to suppose that the mutations are so common and varied as to supply the needed ones. To Waddington it is too much to suppose and so he postulates a developmental mechanism.

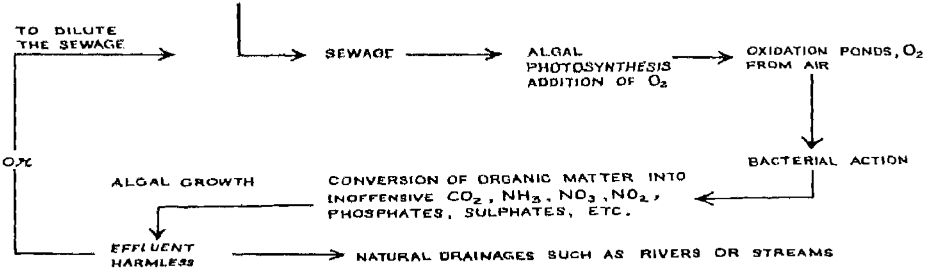
There are still other problems that the theory has not explained. Fisher (1930) summed up the then position as follows: 'The sole surviving theory is that of Natural Selection, and it is impossible to avoid the conclusion that if any evolutionary problem appears to be inexplicable on this theory it must be accepted at present merely as one of the facts which in the present state of knowledge seems inexplicable'. Many such problems have been explained since this was written. But many still remain and the words are true even today. It also implies that with further progress of knowledge the area of the inexplicable will progressively diminish.

Algae in Our Lives—II

S. Doraiswami
Department of Science Education,
National Council of Educational Research and Training, Delhi

ALGAE IN SEWAGE TREATMENT

IN the modern age, the disposal of sewage and industrial wastes is a great problem. As these are rich in organic matter, they emit a foul smell when they decay. The problem is to reduce the organic matter into stable products. In nature the organic matter is broken down by aerobic bacteria which need plenty of dissolved oxygen. The sewage usually is deficient in oxygen and hence the foul smell. In the usual method of sewage treatment extra dissolved oxygen is supplied artificially into the fluid. This involves some expenditure. Recent researches have shown that single-celled algae could be grown in symbiosis with bacteria in open sewage ponds and organic wastes. The photosynthetic activity of the algae would release more oxygen which the bacteria can use for aerobic decomposition of the organic matter in the sewage. As a result of this bacterial action, ammonia, carbon dioxide, sulphates, nitrates and other products are released which the algae can use for their growth. Thus algae are useful in the biological treatment of sewage, because the oxygen they produce is made available for the biological oxidation of sewage without any equipment or expense.


TO DILUTE THE SEWAGE
SEWAGE
ALGAL PHOTOSYNTHESIS ADDITION OF O_2
OXIDATION PONDS, O_2 FROM AIR
BACTERIAL ACTION
OR
ALGAL GROWTH
CONVERSION OF ORGANIC MATTER INTO INOFFENSIVE CO_2, NH_3, NO_3, NO_2, PHOSPHATES, SULPHATES, ETC.
EFFLUENT HARMLESS
NATURAL DRAINAGES SUCH AS RIVERS OR STREAMS

The sewage is impounded in shallow, open, out-door ponds which are referred to as oxidation ponds or stabilization ponds. The treated effluent is allowed to flow out at the other end. The treated water may even be used for irrigation of agricultural land if the algal population could be screened off. The detention in the stabilization ponds makes the water less offensive and may even contribute to the fertility of the land.

The algal organisms which are formed in sewage ponds and whose growth could be encouraged are *Chlorella pyrenoidosa*, *Scenedesmus obliquus* and *Euglena viridis* There is another advantage in this culture of *Chlorella* in sewage ponds. The possibility of using *Chlorella* as a subsidiary food or for producing cheap proteins has been discussed in the earlier paper (Doraiswami, 1963) The presence of *Chlorella* in polluted waters has suggested to workers the idea of using these detention ponds not only to treat the sewage but also to produce cheap proteins without any additional cost for growing these organisms. The idea is now being vigorously pursued in the U S.A. The sewage treatment problem was also investigated sometime back in Madras.

Biological Possibilities of Mass Cultures of Algae

In recent times there has been a growing interest in the mass culture of algae, not only as a possible source of food but also for other industrial purposes. Scientists in the U.S.A., Israel, Germany and Japan are examining the possibilities of using algae as a source of energy *Chlorella* mass culture can also be utilized to use the dried cells as fuel for combustion which ultimately produces electricity.

The solar energy that a one and one-half square miles of earth's surface receives in a day is said to be equal to the energy released by the explosive of an earlier atomic bomb. *Chlorella* is more efficient in using sunlight and trap it as chemical energy than other higher green plants. A culture of unicellular algae can be undertaken as an industrial process where a continuous process under controlled conditions is possible. Perhaps the day is not far off when the chemical energy trapped by mass culture of algae can be converted into electricity.

ALGAE IN INDUSTRY

Apart from those using algae for food products, there are many other industries which produce useful substances. Algin, agar-agar and carragheenin are some of these besides the potash and iodine industries. The latter two are not so extensive now because these products could be obtained more economically from other sources.

Kelp: It was not until the 17th century that the kelp industry developed. Kelp is a word which is generally applied to the seaweeds, though originally it referred to the burnt ash of the brown seaweeds. The algae most commonly used in the kelp industry were species of *Laminaria*, *Fucus*, *Ascophyllum*, *Macrocystis*, *Nereocystis* and *Alaria*. The seaweeds grow in abundance in the temperate waters. These are collected as cast off seaweeds or cut off the rocks on which they grow. The ash of this kelp was used to manufacture soda, potash and iodine. Soda and potash are used in the making of alkali for the manufacture of soap and alum. The discovery of salt deposits in the 19th century caused a setback to the kelp trade of Europe. Japan still manufactures about 5.7 per cent of the world's supplies of iodine from kelp. France, Norway and Java obtain iodine from brown seaweeds, while Russia manufactures it from a red alga *Phyllophora nervosa*. But 80 per cent of this world supply comes from the nitrate mines in Chile. But in spite of the failure of the kelp industry with regard to these two products it forms a background to another major industry, *viz.*, the production of alginates.

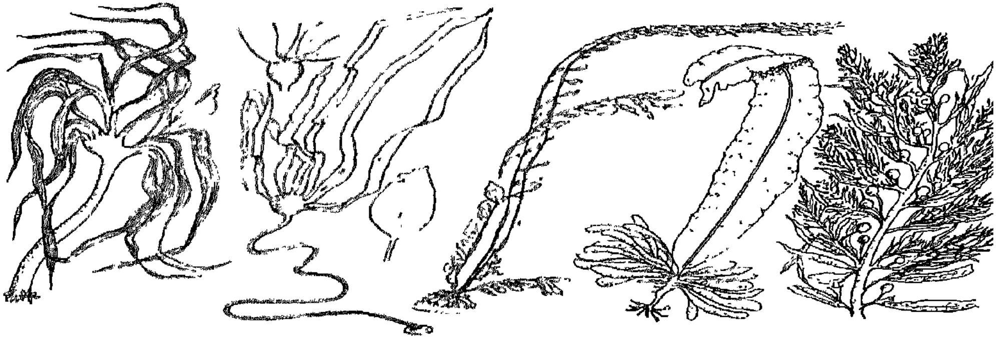


Fig. 1. Fig. 2. Fig. 3. Fig. 4. Fig. 5.

Figs. 1–5. Some seaweeds. 1. *Postelsia palmaeformis*, 2. *Nereocystis luetkeana*, 3. *Macrocystis pyrifera*, 4. *Alaria esculenta*, 5. *Sargassum filipendula*

There are three kinds of colloids prepared from algae and they will be considered here.

Algin: Algin is a mucilaginous product obtained from kelps when they are soaked in fresh water. Algin and alginates have assumed great importance since 1940. Algin is extracted from the seaweed as alginic acid or as calcium or sodium alginate. The alginates are used in the production of plastics and artificial fibres. Alginic acid is insoluble in cold water but absorbs many times its weight in water. When dry it becomes very hard and horny. More important use of algin is as a stabilizer in ice-creams and sherbets. In ice-cream it prevents the formation of ice crystals and makes the ice-cream smooth. It is used as a filler to candy bars and in salad dressings. The insoluble salts have been used in the production of waterproof cloth. Vegetable stabilizers like agar, algin, and Irish moss are preferred wherever there is objection to the use of animal gelatin. Algin is valuable as a sizing substance.

Algin is used in boiler water treatments. It reacts with calcium in hard waters and is precipitated as calcium alginate, formed as flocculent masses. These can be removed at intervals. This expedient prevents scale deposits on the boiler walls.

Agar: The production of agar-agar is a major seaweed industry today. Many are familiar with its use in the culturing of fungi and bacteria. For hundreds of years it has been used as sweetened and flavoured gels. It is available in the local markets as 'China grass'. Agar was discovered accidentally by a Japanese, about 300 years ago. He discarded some agar gel into the cold weather. Here it froze and upon thawing lost most of its water and when it dried, it was a white fluffy matter. The

Japanese found that he could use this again to make a gel. This led to the development of the industry.

Japan has long been the world's leading producer of agar and had a monopoly in its trade till World War II. At the outbreak of World War II there was a great shortage of agar in all countries. Necessity drove these countries to explore alternative sources. A large number of genera and species of seaweeds are used as the source of agar. The plants from which agar is extracted are called agarophytes. Most of these are red algae, the principal ones being *Gelidium cartilagineum*, *Gracilaria lichenoides* and *G. confervoides*. The weed is first collected, dried and bleached. It is then boiled in water which extracts the gelatinous material. This is then strained and purified by freezing. When thawed, the water flows away along with the impurities

Agar is the gel forming extract from these algae. It is insoluble in cold water but soluble in hot water, a 1 per cent solution of which forms a firm gel. Those from other algae which do not form firm gels are called agaroids.

There are three types of agar, the *Gelidium* type which sets firm even when dilute; the *Gracilaria* type which sets firm when more concentrated and the *Chondrus* type which sets firm only if very concentrated.

Besides its use in bacteriological culture work, agar is used along with glue in adhesive preparations, as a substitute for gelation; in foods as substitute for white of egg, and a thickening agent in ice-creams, sherbets and pastries. In medicine, agar is used as a laxative and for dental plate impressions. In cosmetics it is used as an ingredient of greaseless creams, ointments and lotions. In textiles it is used to size paper and silk.

Carragheenin: The extract from Irish moss or *Chondrus crispus* is known as carragheenin. This substance is similar to agar, but has a higher ash content and a lower gel strength. The most important use of carragheenin is as a stabilizer in chocolate, milk, ice-creams, sherbets, salad dressings and fruit syrup.

In medicine it is used in emulsions and tablets. It is used in insect sprays, in sizing of cloth and paper. Irish moss powder is used as a clarifying agent in breweries. The cloudy solution of malt extract contains insoluble and unwanted proteins. These can be removed either by settling, which is a tedious process or by 'fining'. Irish moss is added to the brew while it is boiling. The gelatin freed from the weed unites with the tannin from hops to form a flocculent scum enclosing the impurities. The scum is skimmed off.

It is a common belief that coral reefs and atolls are generally formed by the skeletons of stony corals. What is not so commonly known is the fact that the skeletons are cemented together by coralline algae and the lime shells of other marine organisms. It is not impossible for some rock formations to be formed entirely of the lime secretions of algae alone. Certain marine algae *Lithothamnion* and *Halimeda* are important agencies of precipitation of lime in the form of coral reefs. Blue green algae have also been responsible for vast stretches of limestone beds. It is believed that large deposits of lime found in the sedimentary rocks of early geological eras were produced by algae similar to the present day blue-greens. Around the basins of many hot springs may be seen the coloured deposits of travertine and sinter which are the result of the deposition of calcium carbonate from the water.

Fig. 6

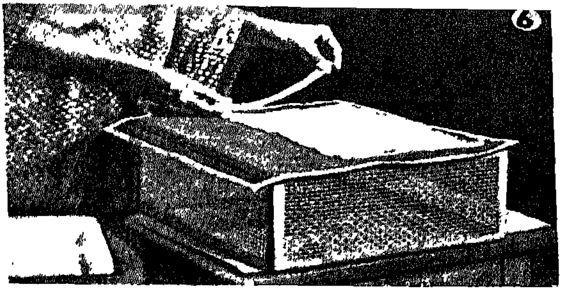


Fig. 7

Fig. 8

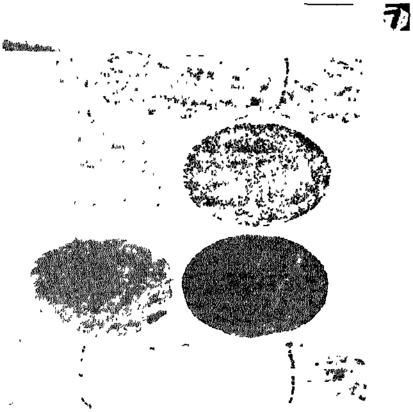


Fig. 9

Fig. 6-9 Stages in the preparation of agar. 6. Raw materials, *Gracilaria* and *Gelidium*. 7-8 Agar strips on frames. 9. Finished products in the form of stips or flakes.
From *Symposium on Algology*, I.C.A.R.

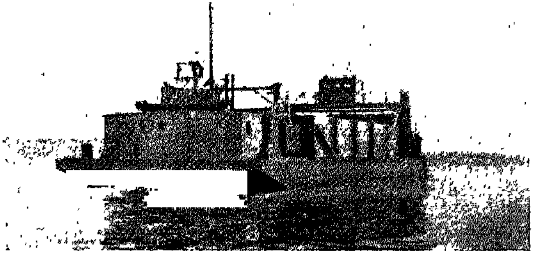


Fig 10

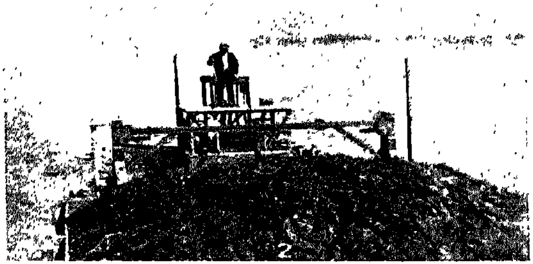


Fig. 11

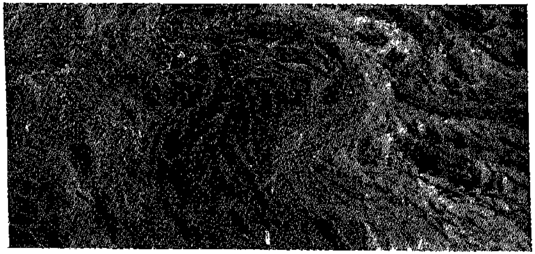


Fig. 12

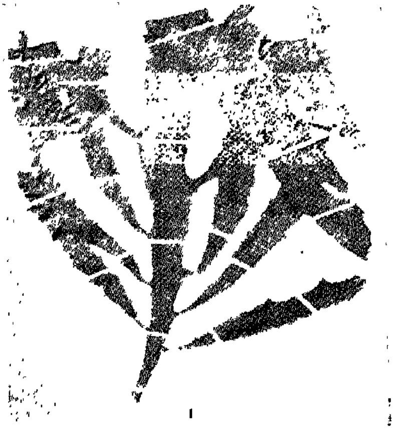


Fig. 13

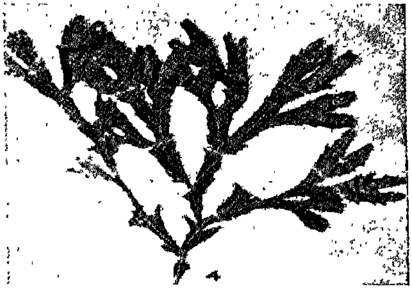


Fig. 14

Fig 10 and 11. Harvesting of kelp. **Fig. 12.** *Macrocystis pyrifera.* **Fig. 13** *Ecklonia cava,* Fig 14. *Fucus serratus.*

As the algae use the dissolved carbon dioxide for their photosynthesis the lime is deposited. Calcareous pebbles often show a radial concentric structure which is associated with growth of *Gloeocapsa* and *Gloeothece*. Deposits of marl in Michigan are said to be due to *Chara* which absorbs carbon dioxide from water saturated with calcium salts and precipitates the lime on the 'leaves' of the plant.

Another very unique group of organisms which has contributed to the formation rock beds are the diatoms. These are unicellular with two halves of cell walls which overlap and fit together like the two halves of a pill capsule. Their cell walls are impregnated with silica in definite patterns. When the organisms die the cell-walls fall to the bottom and, because of the silica, they are well preserved. Over millions of years these deposits have collected and formed into rocks, due to pressure. During the Mesozoic era the diatoms and dinoflagellates reached their maximum production and abundance in the oceans. The deposits of those days are now exposed in some areas and these rock beds are now quarried as diatomaceous or Fuller's earth. Some of these beds are very extensive. One of the largest is in California near Lompoc, which covers 12 square miles and is 14,000 ft. high. It consists of pure diatoms. One cubic inch of this rock will hold 40,000,000 individuals.

Diatomaceous earth is used in toothpastes and powders, in silver polishes and in other polishing material. Because of their fine structure, these powders polish well without scratching. Diatomaceous earth is used for filters in sugar refineries; and as bricks they are used as insulators in boilers and furnaces. It is also used for transporting dynamite.

Diatoms store oil in their body as part of their food. According to one view all petroleum deposits are formed by the decay of animal and plant life. The places where oil is now found were once under the sea. Countless number of animals and plants which lived in these oceans must have settled in layers at the bottom after their death. Over this were laid layers of sand and mud and these were gradually turned into rock. Very small holes and pores in the rock held tiny droplets of oil and bubbles of gas which were all that remained of the living cells. These rose upwards till they came to a layer of rock that had no pores.

ALGAE IN UNUSUAL PLACES

So far we have considered various algae in their natural habitats and their uses. We may as well consider algae living in unusual places. Mention has been made of soil algae, but truly terrestrial algae may be found on tree trunks, like *Trentepohlia*. *Cephaleuros virescens* is a parasite on tea (Red rust of tea). Many are epiphytes or epizoophytic as those on shells of snails or gastropods. Some adopt a hitch-hiking technique. They ride on other moving unicellular organisms and thus derive all advantages of a motile organism, though they are themselves attached. An example is *Characium* on *Closterium*.

Some algae are endophytic, such as *Entocladia* inside *Rhizoclonium*. *Anabaena* lives in *Azolla* and a species of this is even reported in the leaves of the Egyptian clover—*Trifolium alexandrinum*, and every college student knows that *Nostoc* dwells in the coralloid root of *Cycas*.

Algae in association with fungi form a compound structure the lichens. A sloth carries on the scales of its hairs a red alga—*Cyanoderma*. Certain species of algae are found even in the intestines of man and animals. Zoochlorellae are found growing symbiotically with Infusoria. A species of red alga lives in cells of sponges. Some animals of the protozoa and coelenterate groups can live without feeding because they have in them green algae.

Thus it may be seen that algae—the 'mere pond scum' of which no one takes any notice—are so intimately associated with lives of men.

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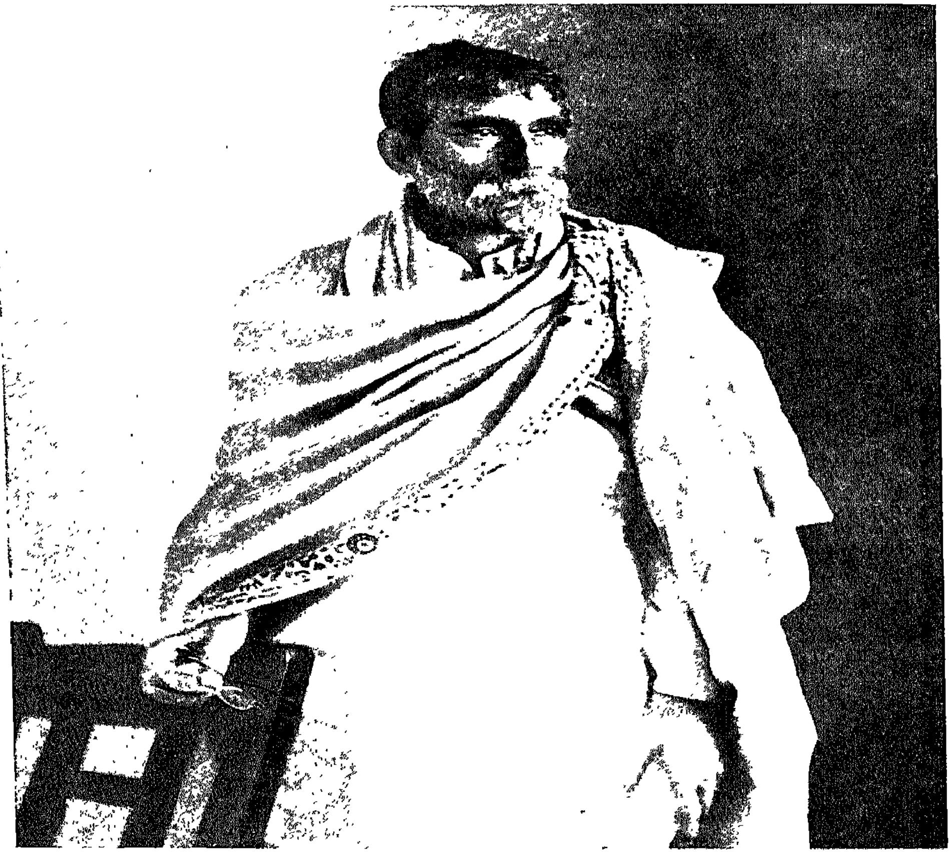

Prafulla Chandra Rây

Acharya Prafulla Chandra Ray—(1861-1944)

N. R. Dhar
Sheila Dhar Institute of Soil Science,
University of Allahabad, Allahabad

IN my Presidential Address to the Science Congress at Roorkee inaugurated by our former President the late Dr. Rajendra Prasad, I stated that the present progress of science and technology in India has to be attributed to the achievements and devotion to science of Acharya P.C. Ray, Acharya J.C. Bose and Sir C.V. Raman. Acharya Ray, with whom I was intimately associated for over 37 years, i.e., from 1907 to 1944 made four notable contributions to the advancement of the Indian nation :

1. Introduction of active research work in science in the Indian colleges and universities.
2. Inspiring young Indians to follow scientific pursuit seriously.
3. Promotion of the utilization of raw materials and natural resources available in the country for the manufacture of chemicals and drugs.
4. Placing before the world the early Indian achievements in science and medicine in his book *History of Hindu Chemistry*.

His researches on the isolation and properties of the new compounds mercurous nitrite, ammonium nitrite and amine nitrites and other nitrites have found an important place in textbooks on chemistry. His devotion and love for research was contagious and he inspired a large number of young chemists to take up scientific problems, and thus research work became a regular programme not only in the Presidency College, Calcutta, where he toiled for over 28 years but also in the Science College which was established by Sir Ashutosh Mukherjee. On numerous occasions Acharya Ray put forward before the Senate of the Calcutta University and elsewhere the legitimate claims of scientific education and research in Indian Universities.

Consequently, the facilities for research work in Calcutta in the Presidency College, Science College, Indian Association for the Cultivation of Science, Jadavpur, Bose Research Institute, Glass Research Institute, Jute Research Institute and many Government laboratories are almost as good as in any capital city of any industrially advanced country.

Mr. H.R. James, Principal, Presidency College, Calcutta, stated in 1912 that Dr. Ray was successful in developing the chemical industry in Bengal where businessmen had failed. The Bengal Chemical and Pharmaceutical Works started by Acharya Ray soon after his return from Europe in 1888, is perhaps the biggest concern of this type in the whole of the East.

His writings and publications reveal high sentiments and feelings and great concern about the poverty of our people.

In reviewing his autobiography, *Life and Experiences of a Bengali Chemist*, the famous British scientific weekly *Nature* wrote: 'From the beginning to the end the message of the book is one of the highest endeavour—pulsating with vitality and intellectual force'. It is no wonder such a great man possessing marked ability, great honesty of purpose, extremely methodical habits, tremendous energy of action and thought, instinct of immense self-sacrifice, great patriotism and above all supreme love for his pupils and for the suffering man, was adored by the youth of India, and his influence has spread all over the country through his pupils.

RESEARCH

He made notable research in nitrite chemistry since 1888. From 1910 onwards, he was keen on the investigation of nitrites from a physico-chemical point of view. Along with Prof. S.C. Mukherji in 1910-12, he carried on researches on the freezing points of nitrite solutions. In July 1911, when I humbly suggested to him that the electric conductivity measurements of some nitrite solutions may be taken up by me, he was exceedingly delighted and asked me the question, 'Can it be done in this country?' It was felt at that time that conductivity water could not be prepared in our country. With the active cooperation of Prof Ray, electric conductivity water was prepared for the first time in this country in a small room, rather a cellar, at one side of the stairs of the Presidency College, Calcutta, in 1911. With this conductivity water, the electric conductivity of almost all the soluble nitrites was determined and several papers were published, specially in the *Journal of the London Chemical Society*, and these received favourable comments from the late Professors Sir Henry Roscoe, H.B. Baker, Sir William Tilden, Sir Gilbert Morgan and others. These results have been embodied in numerous textbooks in inorganic and physical chemistry. His discovery of mercurous nitrite and researches on nitrites, hypo-nitrites, vapour density of the unstable substance ammonium nitrite, organic sulphur compounds, valencies of gold, platinum and other metals are of great importance, and raised him to the rank of an eminent scientist. The later generation of Indian chemists would do well to study these original papers in the periodicals of the London and Indian Chemical Societies.

PUBLICATIONS

His monumental publication, *History of Hindu Chemistry* in two volumes attracted well-merited praise all over the world. Men like Marcelin Berthelot, Sir Henry Roscoe, Sylvain Levi and other great authorities have described it as a publication of great merit and value in the history of sciences. For the first ime, an Indian chemist conclusively proved that the Hindus were great pioneers in steel making, caustic alkali preparation, and in the medicinal applications of iron and mercury products, and that they were very much ahead of people of other nations who adopted these procedures from our country. Intellectual superiority of the Hindus, even in the domain of practical science and its applications, was established with great ability and authority by Prof. Ray and this is a contribution of first rate importance to an Indian nation which has a big past and has perhaps, a very big and promising future.

INDUSTRIALIZATION

For over 40 years he preached the gospel of industrialization of our country.

He taught us that the wealth and prosperity of the country cannot increase without the development of industries. He maintained that the raw materials available and produced in this country should be worked out into finer products by Indians in Indian mills, factories and workshops owned by Indians and worked with Indian capital. Agricultural pursuits alone, even scientifically carried out, cannot solve the problem of poverty in this country, and he emphasized that India must produce all the materials consumed in this country. This was a great forethought, the benefits of which we have just begun to reap.

The Bengal Chemical and Pharmaceutical Works, of which he was the founder, is a first-rate practical demonstration of his precepts towards the industrialization of the country. For nearly 50 years this concern was his heart and soul and due to his sacrifice and labours, it is the biggest manufacturing enterprise for drugs in the whole of Asia, proving to be an immortal edifice to the credit, ability, sterling character and sacrifice of this great pioneer. All his life, he insisted on young men and women not to rely on jobs but to go into business and industries and he urged us all to follow the example of the Marwaris. His advice is, I am happy to see, being followed by many.

UNIVERSITY COLLEGE OF SCIENCE & TECHNOLOGY

Acharya Prafulla Chandra Ray was instrumental in arousing the enthusiasm of the great educationist of India, Sir Ashutosh Mukherjee, for collecting funds for the establishment of the University College of Science and Technology. When the Professorships of the Ancient Indian History and Culture and Philosophy were created in 1910-11, Acharya Ray made a strong plea in the Senate for the creation of Chairs for Science in the Calcutta University. Sir Ashutosh, who was the Vice-Chancellor at that time, assured him that he was hopeful about creating Science Chairs in the immediate future. The Calcutta University was only an examining body before 1910. Sir Ashutosh tried to completely Indianize the Calcutta University and convert it into a great teaching and national university. He was successful in collecting nearly 60 lacs of rupees from benefactors like Shri T.N. Palit, Dr. Rashbehari Ghose and Dr. Mahendranath Dey and Shri Khaira Raj for the creation of Chairs in pure and applied sciences. Thus a splendid college of Science and Technology, a unique institution of this type, came into existence in 1914. It is interesting to note that one of the chief clauses of the Palit and Ghose Endowments is that none but Indians are eligible for these Chairs.

The other great Institute for Science and Technology in India is the Indian Institute of Science at Bangalore started in 1918 by the munificence and far-sightedness of that great Indian Jamshedji Tata. This Institution was first entirely manned by European pupils of Sir William Ramsay, who came out to India to advise the Tata family and the Government of India for the establishment of the Indian Institute of Science. For the first time Indian scholars had ample opportunity for the teaching of science. This was a landmark in the history of Indian education and technology. All provinces in India had first-grade degree colleges managed by the Government, but the facilities for research were inadequate at these institutions and senior teachers were mostly Europeans.

The example of Calcutta University in concentrating post-graduate instruction at the University may be profitably emulated by other Universities in the country. In the U.S.A. and on the continent in France, Germany, Norway, Sweden and Holland only postgraduate work and research work are carried on in the Universities and technological Institutes and the technical High Schools of University rank, and that is how science and its applications receive a tremendous impetus in these countries resulting in an increase of national wealth. The Calcutta University is rightly following the Continental method and not the English system as typified by London, Cambridge and Oxford Universities where degree work is associated with research work. I may point out that Calcutta shares almost the same privileges for research as a model University centre in Euope.

HUMAN RELATIONS

It has been a good fortune for me that I was in intimate association with my great *guru*, Acharya Prafulla Chandra Ray, since 1907 when we first met. He took me as his puqil and our relationship and association deepened with years till his death in 1944. He was a very kindhearted and remarkably active man and an highly affectionate and inspiring teacher. He adopted me as his intellectual descendent and insisted on my living with him at his house on the top floor of the Bengal Chemical and Pharmaceutical Works Office. He was a great scientist and a nationalist and a true friend of the student community. As the Professor and Head of the Chemistry Department of the Presidency College, Calcutta, he used to draw Rs. 700/- p.m. and out of this he gave away Rs. 350/- every month to the deserving and poor students studying in the colleges in Calcutta. He also contributed Rs. 25/- p.m. to the Brahmo Girls' School, which was run by the late Lady Abala Bose. He used to make similar grants to other educational and charitable institutions. He contributed Rs. 40/- p.m. to the late Dr. H. K. Sen, the eminent organic and industrial chemist during a period of three years when he was studying for a master's degree. His personal expenses did not exceed Rs. 150/- p.m. including the maintenance of a carriage and horse. This was used by him for going to the fort on the lawns of which he took long walks and relaxed after a hard day's work. He literally lived for science, for the country and for his pupils who could not avoid the contagion of his infective zeal for seeking new knowledge. His plain living and high thinking was noble example to the teachers and the taught. He was a healthy combination of idealism, practical commonsense and philanthropy. His mind was intensively active and his thinking clear. I frequently wish that the present generation would follow the footsteps of this great savant.

He was also a very great teacher who may, perhaps, be ranked on par with the greatest teachers like Liebig, Hoffman, Dumas, Bunsen, Ostwald, Perkin, Robinson, Svedberg, Arrhenius and others.

RELATIONS WITH STUDENTS

Sir P.C. Ray's laboratory at the Presidency College and the Science College, Calcutta, has been described by the great Orientalist, Sylvain Levy of Paris, and other great men, as the nursery of Indian chemists. During the period of nearly 50 years he inspired young chemists and physicists by his contagious love of learning and keenness for the advancement of science and its applications, and by his paramount love toward his pupils and country.

He has been the founder of a school of scientists in this country which has contributed a great deal to the developments in science and industry in this country during the last 50 years. His pupils and their pupils are holding Professorships and Research Chairs in most educational and research centres of India. This is a very great achievement.

When I look back to the 50 years of scientific progress in this country, many thoughts crowd in my mind. Have we the devotion and the sacrifice which the pioneers of science in Europe have shown? Has the new generation of Indian scientists the perseverance and doggedness and devotion of Sir J.C. Bose or Sir C.V. Raman? Why do we not work as hard as the average French or German teacher? Perhaps the last 50 years were like the apprenticeship period of Indian science just as the first 50 years of the 18th century were the apprenticeship period of European chemistry. The great achievements of Priestley, Cavendish, Scheele, Black, Lavoisier and others and the rich harvest of scientific discovery were reaped in the last half 18th century.

When I think of the great and the kind man and the deep and abiding love, kindness, tenderness and sunshine received from him and the happy and inspiring years spent at his feet in close association, my heart is filled with joy and deep gratitude that such a prince of princes amongst men was born, who was by preference and choice a socialist, saint and a fakir.

My invincible belief is that finally science and peace will triumph over ignorance and war, and that nations will unite not to destroy but to help each other, and the future will belong to those who have done most for the suffering humanity. India is going to take its rightful place in this true progress and onward march of civilization, and the name of our great *guru* will be ranked along with those of Raja Ram Mohan Roy, Swami Dayanand, Swami Vivekananda, Sir J.C. Bose, Rabindranath Tagore and Mahatma Gandhi and others in the making of India great nation.

Further details of the life of Acharya Prafulla Chandra Ray reproduced below are extracts from the article by Sri P. Ray in Sci. & Cult., 27: 361–68, August, 1961 – Ed.

Acharya Prafulla Chandra Ray (1861—1944)

THE year 1861 was an eventful year for India, as in that year three great eminent sons of her, Rabindranath Tagore, the great poet and thinker, Pandit Motilal Nehru, a great political leader and a fighter for the freedom of our country and Acharya Prafulla Chandra Ray were all born.

Acharya Ray was born on August 2, 1861 in Raruli-Katipara, a village in the district of Khulna (now in Pakistan).

Born of a distinguished well-to-do middle class family, Prafulla Chandra started his early education in a village school. His father, Harish Chandra Ray, was well versed in Sanskrit, Persian and English languages, and acquired a reputation for his learning and liberal views. The habit of free and rational thinking, which was a dominating feature of Prafulla Chandra's life, might be traced to the influence of his father as its origin. His subsequent training in the Albert School and the Metropolitan Institution in Calcutta brought him in contact with the great religious reformer Keshab Chandra Sen and with Surendra Nath Banerjee, the father of Indian nationalism. The eloquence of the former surcharged with religious fervour, and of the latter with passionate, patriotic appeal, left an abiding impression upon his mind. Service of his fellowmen and work for the regeneration of his mother country, which afterwards became the mission of his life, were thus presented to him as objects of high endeavour, and he was not slow to be profoundly influenced by these ideals. Though an ardent student of literature and history, he used to attend, while a student in the Metropolitan Institution the lectures of Prof. Pedler on chemistry at the Presidency College, which stirred his imagination and aroused his interest and curiosity in chemistry. Pursuit of truth by the experimental method of science and its rational process of thinking at once made a strong appeal to young Prafulla Chandra's mind. At the same time he did not fail to foresee that the future progress of India was closely bound up with the progress of science in the country. So, in spite of his predilection for literature and history, he took up the science course for his B.A. examination with a view to studying chemistry at the higher stages. But he did not give up his interest in literature and history, and continued the study of economics and politics. He also learnt Latin and French.

In 1882 Prafulla Chandra left for the United Kingdom on the Gilchrist scholarship and studied for six years in Edinburgh University. There he came under the influence of Professors Tait and Crum Brown. Crum Brown was one of the most philosophically minded chemists of the time and it is not surprising that Prafulla Chandra was naturally attached to him.

In 1885, while a student in the B.Sc. class of the Edinburgh University, Prafulla Chandra competed for the award of a prize by the University for an article on India before and after the Mutiny. Though not considered the best, Prafulla Chandra's article was declared by the examiners as the nearest approach to the best. The article was full of diatribes against the British rule in India, replete with sub-acid humour. Nevertheless, it received unstinted praise from its examiner, Sir William Muir, the Principal of the University. A reprint of the article was presented to the great Parliamentarian, John Bright, who was regarded as a friend of India. Bright's sympathetic reply to Prafulla Chandra, which appeared in all the leading papers of the United Kingdom with the head-line 'John Bright's Letter to an Indian Student', created a stir in the political circles of England at the time. Prafulla Chandra, encouraged by the result of his first excursive effort in the literary field, published in 1886 his *Essay on India* in the form of a booklet which administered a mild warning to the British of the disastrous consequences of their reactionary policy in India.

In 1887, Prafulla Chandra was admitted to the D.Sc. degree of the Edinburgh University for his research work in chemistry, and was also awarded the Hope Prize

Scholarship of the University. The members of the Chemical Society of the Edinburgh University elected him as the Vice-President of their Society, of which Prof. Crum Brown was the President.

In 1888, Prafulla Chandra returned to India and was appointed in 1889 as Assistant Professor of Chemistry in the Presidency College on a salary of Rs. 250/- only. During the 28 years he served in this college he built up a great reputation as an inspiring teacher, an ardent investigator, and as a historian of chemistry of rare critical judgment. Inspired by his teaching and by the example of his life of ascetic self-denial dedicated to the service of the country and the humanity, and above all attracted by his very lovable and sympathetic personality, bands of brilliant young men flocked round him in his laboratory, leading to the formation of a nucleus of Indian School of Chemistry. He thus came to be the pioneer of chemical education and chemical research in India.

Prafulla Chandra's method of teaching was a departure from the beaten track of pedagogic convention. His lectures to the class were not only illustrated with numerous experiments, but were interspersed with inspiring anecdotes from the lives of great masters and pioneers of science. These he would narrate almost dramatically with a view to making a bridge between the minds of his pupils and the makers of modern chemistry like Priestley, Lavoisier, Scheele, Cavendish, Dalton, Berzelius, Liebig, Wohler, etc. The stories of their struggles and ultimate victory were meant to serve as an inspiration to the impressionable young mind. He also took good care to make his lectures flavoured with apt citations from Shakespeare, Emerson, Madhusudan and Rabindranath, who were his favourite writers as well as from many Sanskrit alchemical treatises like *Rasaratnakara* by the great Indian alchemist Nagarajuna, and *Rasaratnasamuchchaya* by Vagbhata He would not forget to weave into his lectures even matters relating to social and political regeneration of the country. For, he realized that the education to be effective and useful must form an integral part of our life and not serve as a mere appendage or garment for display.

He would not care to adhere to any presscribed textbook or syllabus. Textbooks with their limited contents, he would assert, could seldom satisfy the curiosity or craving for learning, they were of use in that they served as reference books.

Ever since he took up science course and adopted chemistry as the special subject of his study, he cherished a desire for the application of knowledge of chemistry that he would acquire for the welfare of his country through the development of chemical industries. After five or six years' service in the Presidency College, when he gained some confidence in his ability as a teacher and investigator, Prafulla Chandra thought of giving a practical shape to his ideas and decided to set an example himself.

He started preparing common pharmaceutical products for the market in his own house at 91, Upper Circular Road, from the locally available raw materials, the savings from his own meagre salary supplied the capital for his enterprise. After some struggle and uphill fight against adverse circumstances he succeeded with the help of one or two friends as partners to open a small pharmaceutical works under the name, Bengal Chemical and Pharmaceutical Works. It is now a well-established chemical and pharmaceutical works in the country providing employment for thousands of workers.

History of science and particularly the history of chemistry had always a fascination for him. A letter from the illustrious French savant M. Merthelot in 1897 asking for information about Indian alchemy served as an inspiration and impetus to Prafulla Chandra for compiling a *History of Hindu Chemistry*. This monumental work has been rightly acclaimed by all competent critics as a valuable contribution to the history of science. It has proved to the world at large the antiquity of the knowledge of chemistry in this country and of several chemical processes unknown to the rest of the contemporary world. It has undoubtedly helped in infusing a justifiable sense of national pride in the Indian mind.

Prafulla Chandra's researches in the Presidency College chemical laboratory on mercurous nitrite and its derivatives followed by those on amine nitrites and the determination of their vapour densities, brought him due recognition from abroad, and before long his laboratory became the 'nursery from which issued forth the young chemists of New India.'

In 1912, when he visited England to represent the University of Calcutta at the Congress of the Universities of the Empire, held in London, he read a paper before the Chemical Society on one of his latest work, the vapour density of ammonium nitrite. Sir William Ramsay congratulated him on his fine work, and Dr. V.H. Veley welcomed him 'as an illustrious representative of a great Aryan nation which had attained a high degree of civilization and discovered many chemical processes when this country was but a dismal swamp'. In recognition of his extensive work on nitrites, Professor Armstrong in 1914 named him 'Master of Nitrites'.

In 1912, he received the Honorary Degree of D.Sc. from the Univesity of Durham, and the title of C.I.E. (Companion of the Order of the Indian Empire) was conferred on him by the British Government.

In 1916, Prafulla Chandra retired from service in the Presidency College and joined the newly started University College of Science as Palit Professor of Chemistry, to which he was invited by Sir Asutosh Mookherjee, the then Vice-Chancellor of the Calcutta University. Here he was provided with better opportunities for research. In grateful recognition of devoted and selfless service to the cause of chemical education, chemical research and chemical industries in India his pupils and admirers added the honorific epithet Acharya (the great teacher, *guru*, literally meaning dispeller of darkness or giver of light) to his name. The British Government further honoured him with Kinghthood in 1919. In 1920, he was elected the General President of the Indian Science Congress.

Research activities in the chemical laboratory of the University College of Science continued to expand, leading to the consolidation of the Indian School of Chemistry and to the formation, as a logical consequence, of the Indian Chemical society in 1924. The Society was started under his guidance and with a liberal financial assistance from him, and he was elected its Founder-President for the first two terms. Some of his distinguished pupils took a leading part in its organization. The Society has now received its due recognition in the world of chemical science. The part which he had thus played in the development of chemistry in India entitled him in all rightfulness to the significant appellation, the Father of Indian Chemical Science, attributed to him for the first time by a distinguished British scientist, the late Prof. F. G.

Donnan of the University College of Science, London, in his contribution to the 70th birth day commemoration volume of Acharya Ray.

On the completion of his 60th year in 1921, Acharya Ray made a gift of all his salaries to the University of Calcutta from that date onward as long as he would be entitled to it by the retention of his service by the University. It was stipulated, however, that the money thus accumulated should be spent for the extension and development of the Department of Chemistry in the University College of Science and Technology, as well as for the creation of two research fellowships in chemistry in his name, each with a value of Rs. 200/- per month. In 1922 he made a further donation of Rs 10,000/- for an annual research prize in chemistry named after the great Indian alchemist, Nagarjuna. A second endowment of Rs. 10,000/- was made at the time of retirement from the University service in 1936 for a research prize in zoology and botany, named after Sir Asutosh Mookherjee.

Acharya Prafulla Chandra was the recipient of many honours from different quarters. The Universities of Calcutta, Dacca and Benaras conferred on him the Honorary Degree of D Sc. The Deutsche Akademie of Munich elected him an Honorary Fellow of their organization, and in 1934 the London Chemical Society did him the same honour.

In 1932, Acharya Ray published the first volume of his autobiography, *Life and Experiences of a Bengali Chemist* which he dedicated to the youth of India with the hope of stimulating their activities for the service of the country. It might be noted here that though he called himself a Bengali chemist, yet he took good care to dedicate his book to the youth of India.

The second volume of the book was published in 1935. These furnish ample evidence of his knowledge of literature and history and demonstrate that his hand could wield the pen in the literary field with as much ease as he could handle the test-tube in his chemical experiments. A Bengali version of the book, prepared by himself, appeared in 1937 under the title, *Atma Charit*

Though essentially a teacher and investigator in chemistry Prafulla Chandra lived as much an active life outside the test-tube as that in association with the latter. There was no realm of human interest in which he did not make some contribution of abiding value. He was a thinker of sturdy independence and a disputant of sub-acid humour with no variance between his professions and practice He adopted work and service as the motto of his life, and conducted with a crusading spirit a regular campaign against all evils—intellectual, social, economic and political—standing in the way of the progress of the nation. His unbounded sympathy for his fellow men, particularly the distressed and downtrodden, kept him active all through his life working for their relief and uplift.

He was a relentless critic of the system of our school and university education in vogue, as already discussed. He, therefore, became a great supporter of national education and also served for some years as President of the National Council of Education which was established after the partition of Bengal in protest against the system of education under the control of an alien ruler.

Prafulla Chandra was a pioneer of social reform in the country. He was ever eloquent and forceful, in his numerous speeches and writings for the removal of social inequalities and injustices like caste system and untouchability which create division and breed hatred between man and man, as well as for the abolition of cruel and evil practices like early marriage, dowry system, rigours of widowhood, purdah system, etc., which stand in the way of our social progress. He did not believe that political freedom could be achieved, or might have any value for a nation with its social slavery remaining in a dominant position. He therefore, fought for the emancipation of women, for the restoration of their dignity and for the equality of oportunities to them for the enrichment and fulfilment of their lives.

In times of natural calamities Acharya Ray was always the first man to respond to the call of humanity by organizing relief work for the people in distress. His services in connection with the Khulna famine of 1921, and the North Bengal floods of 1922 and 1931, when relief operations were organized under his guidance on extensive scales, have become a part of the historical record in the administration of Bengal.

During his tour of the flood-stricken areas of North Bengal in 1922 Prafulla Chandra came in close contact with the villagers and made a thorough study of the economic condition of the villages. He found that the villagers remained practically unemployed and idle for about 6 months in a year from the time the crops were harvested till that of fresh cultivation in the next monsoon. Thinking seriously how to provide employment to millions of villagers in India and save them from semi-starvation Prafulla Chandra hit upon the idea of introducing the spinning-wheel (*charkha*) among the villagers as the 'poor man's insurance against unemployment and famine.' He then became an ardent follower of Mahatama Gandhi who had just launched his non-cooperation movement for the attainment of *Swaraj*. Prafulla Chandra, a pioner of large-scale scientific industries, became overnight an apostle of *charkha* and *khaddar* and himself started spinning regularly every day and used nothing but *khadi* till the end of his life.

Prafulla Chandra was known for his charity. He gave away freely the major portion of whatever he earned in his life for the benefit of poor students, for helping various educational institutions, and for public and social-welfare services. Besides his handsome donations to the University of Calcutta mention may be made of his financial help to the City College, Calcutta, Bagerhat College of Khulna, and a school in his native village of Raruli, founded in the name of his father. He also made a trust deed for the benefit of poor widows and orphans and for *khadi* work. Finally, the Sadharan Brahmo Samaj, Calcutta, was made the residuary legatee of his properties. He did not earn much in life, yet he spent like a prince in charity. For, he wanted little and kept even less for himself, following the scriptural maxim : तेन त्यक्तेन भुञ्जीथाः which means 'renounce and rejoice.'

Prafulla Chandra's relation with his pupils was a very close one. He was their friend, philosopher and guide, and his pupils too entertained deepest reverence and affection for him. He used to mix freely with his pupils and maintained in some sense the tradition of the ancient Indian *gurus*. Nothing would have given him more delight than the news of achievement of his pupils. On such occasions he would often repeat his favourite saying : सर्वत्र जयमन्विच्छेत् पुत्रात्, (शिष्यात्) पराजयम् । 'One should seek victory from all quarters but welcome defeat from his sons (disciples).'

From a casual study, Prafulla Chandra's life and activities might appear as a bundle of contradictions. His extreme simplicity and negligence in respect of his dresses, his utter indifferences to manners, appearances and convention do not appear to be in tune with his methodical and punctual habits, his over-whelming heartiness, his sturdy independence and his tenacity of purpose. His utter contempt for power, possession and wealth seems to be at variance with his insistent advocacy for acquiring wealth by the development of industries, business and trade. His efforts for the cause of science and scientific industries seem to contradict his activity for the propagation of the cult of *charkha* and *khaddar*. But a little deeper probe will make it clear that his apparently contradictory and diverse activities are but a poly-faced expression of a comprehensive piece, represented by his love for his fellow men and his spirit of selfless service for their welfare. He imbibed this inspiration for the love and service of his fellowmen in his early age when he came under the influence of Kesab Chandra Sen and the Brahmo Samaj.

We thus find that Prafulla Chandra was a friend of the poor and lowly. He identified himself with the common man and disliked to dwell apart from others in aristocratic isolation. The doors of his house and of his heart were equally open to all, particularly to the people in humbler walks of life He wanted to serve his people, but was reluctant to receive any service from them. In fact even in his old age he was found to wash his own clothes and polish his own shoes. This was the outstanding feature of his greatness which was only overshadowed by his goodness

Acharya Ray was, to use the words of his friend and colleague Acharya Jagdish Chandra Bose, 'a path-finder and originator of work of great utility.' In the words of Mahatama Gandhi he was 'a great and good servant of India,' and in the the words of Rabindranath he was endowed with the divine power of creation, which could not have been possible unless he unreservedly made a gift of himself

Acharya Prafulla Chandra's thoughts, words, and deeds as well as the example of his great life have shown and lighted the right path towards the goal of fulfilment and enrichment of our life, both individual and national. It is for his countrymen, present and future, to march along this path for their own good.

Practical Work in Mathematics

Extension Services Centre,
St. Christopher's Training College, Madras

MATHEMATICS is an abstract subject, but it was invented by man for practical purposes like counting, measuring, surveying, etc., and so it is essential that the practical utility of the subject should be emphasized. This is done by getting pupils to do practical work in and out of the classroom. Pupils solve problems on heights and distances, field surveying, areas and volume, but do they know how to get the necessary data for all these? They know how to construct quadrilaterals, when various sets of measurements are given, but do they know why they should not be satisfied with just one set of measurements, for example four sides and an angle? Unless they do these practically they cannot have a clear concept of the application of the facts and the meaning of the different data provided. Moreover such activities give them enjoyment and the satisfaction of having carried out to completion some useful work.

A few of such practical work, which would make the subject concrete, useful, and interesting, are explained below :

1. Std. VII : Laying out plots of given areas :

Aim : To lay out a plot of area, 3 cents.
Equipment : A surveyor's chain and some pegs.

Procedure : Pupils may select a convenient place for laying out the plot. Now, they realize that they should know the length and breadth of the plot and from the area given they select convenient measurements say 60 links and 50 links.

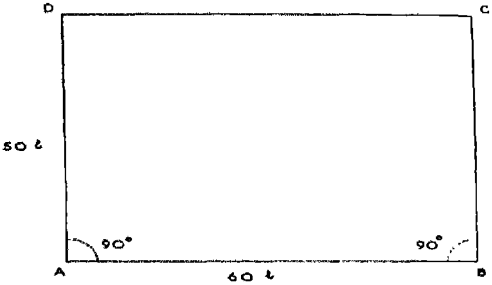

Fig. 1

Using the surveyor's chain they mark off a length AB = 60 links. Then at A and B they make right angles using the ratio 3 :4 :5 and then measure along these lines the length AD and BC, each equal to 50 links. Now, to verify, the fourth side is measured.

2. (A) Std. VII : Finding the capacity of a rectangular tank.

Aim : To measure the length, breadth and height of the tank in order to find out its capacity.

Equipment : Tape marked in centimetres and a pole.

Procedure : Pupils select a rectangular tank and take the internal measurements of length and breadth directly, using the tape. Then the depth is measured by putting the pole inside the tank and marking the edge on the pole, and then they find out the measurement up to the marked level. From these measurements the capacity of the tank is calculated and then given in litres.

Note. a. To find the volume of water in the tank they mark the level of the water on the pole and then measure.

b. The pole is held vertical to the bottom of the tank.

2. (B) STD. X : TO FIND HOW MANY BUCKETS OF WATER THE TANK WILL HOLD

Aim : To measure directly and calculate the capacity of the bucket.

Equipment : Bucket, tape marked in centimetres.

Procedure : Pupils select a standard bucket and measure the vertical height, upper and bottom diametres of the bucket. Using similar triangles, they calculate the height of the smaller cone. For example if 'R' is the upper radius, 'r' the bottom radius, 'h' the height of the bucket and 'x' that of the smaller cone, they then get x from the equation $\frac{x+h}{R}=\frac{X}{r}$ and then substracting the volume of the smaller cone from the larger one they get the capacity of the buket and then find out the number of buckets of water the tank will hold.

Note : This can be done in Standard VII if the contents of the bucket are poured into a rectangular fish tank.

3. STANDARD IX : TO FIND THE HEIGHT OF BUILDING, TREES, AND TOWERS.

Aim : To find the height of a building taking the angle of depression.

Equipment : Clinometer and 100-ft. tape.

Procedure: Pupils divide themselves into two groups. One group goes to the top of the building taking the clinometer while the others stand at the bottom with the tape measure. They select a spot A at a convenient distance from the bottom of the building and place a bright object on the spot so that it is seen clearly from the top of the building Then they measure the perpendicular distance AB from the bottom of the building. The pupil with the clinometer stands at C, vertically above the point B and measures the angle of deprssion ACX, which is equal to the angle of elevation BAC. Then the figure is drawn to scale and the height is obtained.

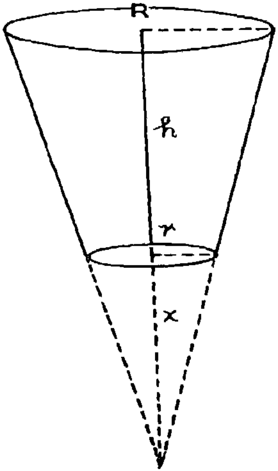

Fig. 2

Note : *a.* The height can be verified by dropping a stone tied to a rope. *b.* If the top is inaccessible, as in the case of a tree, the angle of elevation is taken

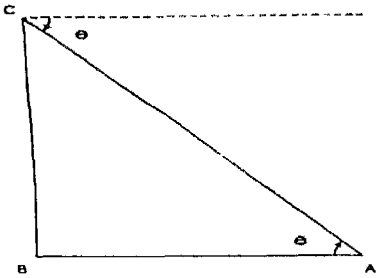

Fig. 3

HEIGHT OF TOWER.

Aim: To find the height of a tower or a mountain.

Equipment: Clinometer and tape measure.

Procedure: Pupils go on a field trip and select a tower. Now, as they cannot get the point B, at the foot which is vertically below the top A of the tower they select two convenient spots C and D which are in a straight line with B, and measure the angle of elevation of the top at C and D. They also measure the distance CD. Then the figure can be drawn to scale and the height of the tower found.

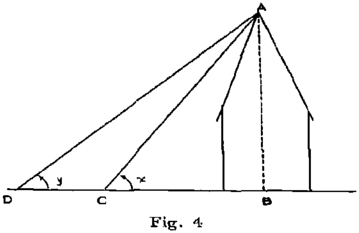

Fig. 4

4 STANDARD X FIELD SURVEYING.

Aim: To find the area of an irregular rectilinear field.

Equipment: Cross-staff, surveyor's chain and a few posts.

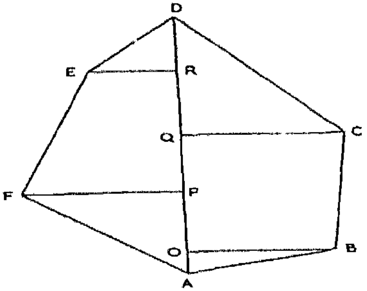

Fig. 5

The cross-staff has a cuboid block of wood at its head with two grooves cut on its upper surface. The grooves are at right angles to each other and it has a long staff attached to its centre so that it could be fixed to the ground (Fig. 6).

Procedure: Pupils select an irregular hexagonal field ABCDEF. They fix a post at each corner. First, any convenient diagonal AD is measured. Then the cross-staff is so adjusted along the diagonal AD held firmly at O so that the staff is vertical to the ground and, while the post at B is visible through one grove, the posts at A and D are visible through the other: 'O' is the foot of the off-set from B to AD. The distances AO and BO are measured. Similarly the off-sets FP, CQ and ER and the distances AP, AQ and AR are measured respectively and the measurements are tabulated in the usual way as shown in Fig. 7.

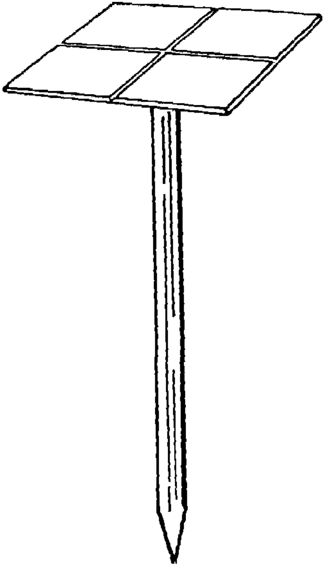

Fig. 6

Then the rough figure is drawn and the sum of the areas of the triangles and trapeziums, will give the area of the field. It can be expressed in cents or acres as required.

5. STANDARD VII—VERTICAL AND HORIZONTAL HEIGHTS.

Aim: To find the vertical height of a station on the slope of a mountain.

Equipment. Poles, pegs, rope and measuring tape.

Procedure Pupils select a spot A on the slope of a neighbouring hill. F is the foot of the hill. A rope is tied to a pole at a convenient height R and the pole is held vertically at F while the rope is held horizontally at E by means of a peg Then the distance FR is measured. This process is repeated until the spot A is reached and the distnce EQ, DP, CO and BN are measured respectively and their sum will give the vertical height of the spot above round.

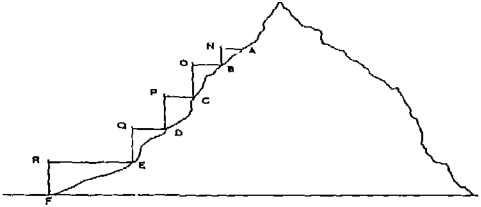

Fig. 8

Note: To get the horizontal distance of the station from the foot of the hill, the horizontal distance should be measured along the rope and added up.

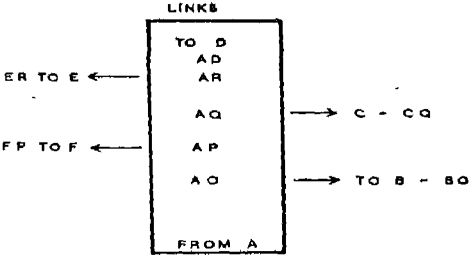

Fig. 7

Science Club Approach in the Teaching of Science

P. Nagaswami
Sponsor, Mufid-Ul-Anam High School Science Club, Hyderabad

WE are living in an age of science, technology, atomic energy and space travel. Science has advanced by leaps and bounds and its impact on society and civilization is considerable. Science is dominating all our social activities and outlook on life. The rapid strides made by science and technology in the last two decades have made science teaching in schools specially in the secondary stage of education very important and significant. The role of science in improving the physical condition of the people and bestowing on them more comfort, wealth and prosperity by tapping the unknown forces of nature is well known. We require a large number of engineers, doctors and technicians to work on National Plans for the material progress of our country. The need for training better personnel with scientific knowledge for the army, navy and air force to defend the frontiers of India and preserve the freedom is the most urgent one today. Hence science education in schools is to be made more efficient and impressive.

It is a matter of regret that in our scheme of science education we are neglecting the laboratory work of the pupils and the use of the hand in the handling of tools, machines and apparatus. Classroom teaching ends with the demonstration experiments by the teacher. Major emphasis is given to factual knowledge and not to the development of skills, interests and appreciations of the pupils. It is needless to say 'that learning by doing' and personal observation are of permanent value in the learning experience of the pupils. We seem to be grossly neglecting this aspect of laboratory work in the science classes at all stages of science education.

THE NEED FOR SCIENCE CLUBS

The Science Clubs provide a means by which we can improve the tone of science teaching. The activities of the clubs are of a practical nature and they create interest in the boys to purposeful and worthwhile activities. By having the science club approach in the teaching of science we can increase the standard of science teaching.

Science clubs of America, U.K. and the Pioneer Palaces of Soviet Union, Farmer's Clubs of Canada are examples where necessary facilities are provided to the pupils to stimulate their interests in science learning. Improvised models are constructed by the boys from cheap and scrap material. The coordination of the hand and the mind is got by engaging the pupils in the manipulation and construction of the apparatus. The use of the hand in creative work and the application of scientific knowledge and interests in every day life is the most impressive way of teaching science.

SCIENCE CLUB ACTIVITIES

An earnest attempt is made in our schools to correlate the activities of the science club to classroom teaching. Projects and assignments in the science club go a long way to enrich the learning experiences of the pupil which supplement the classroom teaching.

One activity of the Science Club is the collection of specimens, such as rocks, ores and minerals for the school museum. Members of the Science Club of this school collected a variety of rocks, limestone, quartz, calcite, granite, iron ore, corals, shells, etc. They were tested in the laboratory for carbonate, silicate and sulphide ores by simple experiments. The minerals were classified and the club members can now explain their findings to the rest of the boys in the classroom. The enthusiasm of the boys in collecting different stones and minerals and studying them is the best way of learning science. Thus the club activity of collection can be correlated with classroom teaching.

Another activity of the science club is the construction of improvised models of kaleidoscope, periscope, telescope, electric bell, electric motor, electromagnet, magnetic compass, and galvanoscope. These can be exhibited to the rest of the boys in the classroom teaching. The study of the improvised apparatus and models creates an interest in the other boys to emulate them.

Field trips and science excursions to glass factory, iron works or any other industrial centre can be arranged by the science club members. The class can be divided into groups and a questionnaire issued to the boys regarding the raw materials used and the details of the manufacture. Boys may be encouraged to observe the working of the factory and discuss the questionnaire in groups. Their findings and experiences can be related in the class. The teacher by suitable questions in the follow-up class should co-ordinate all the facts observed by the pupils into a whole lesson. This method of teaching science lessons will be fruitful. The boys not only are enthusiastic in their work but also understand the subject thoroughly well

Club meetings on the life and work of scientists such as Archimedes, Galileo, Newton, Edison, Marconi, Raman, Saha and Ray can be discussed. In our club the members enacted the scene of King Hero asking Archimedes whether the crown made by the goldsmith was of gold or not. Boys take lively and abiding interest in the lesson. The scientific principles and knowledge are driven home into the minds of the pupils and the learning experiences are more effective by this method of teaching.

CONCLUSION

The above are some of the situations in which the science club activities can be correlated with the classroom activities connected with the syllabus. The teacher can expand these activities by his resourcefulness, and make up for the lack of equipment in the laboratory by purposeful activities in the science club. While using the hand in shaping and constructing the apparatus there is the coordination between the hand and the mind Hence the science club approach in making the boys prepare improvised apparatus has psychological meaning and thinking process. It provides ample scope for the ingenuity and resourcefulness of the pupil in making a spirit lamp from tin cans and glass bottles; and a tripod stand from condensed milk tins It is hoped that science teachers will make use of the science club activities in the classroom teaching and derive maximum advantage from them. Then the science club will surely become a nursery or laboratory for the future scientists and inventors of our country.

Bunsen Burner for the Village

S.S. Maitra

Ananda Chandra Training College, Jalpaiguri

THE biggest difficulty faced in science teaching in our country is the difficulty of obtaining equipment. A scientist can solve this difficulty to an extent which will make science teaching practicable under even the most trying conditions. 'Costly', 'imported' or 'rare' instruments or equipment are not the only corner stones for building up our structure of science teaching. A teacher with imagination may improvise substitutes, devise home-made equipment, modify the experimental procedure and in many other ways cross the hurdle. There are good guide books (like Unesco *Handbook for Science Teaching*) to help us in the matter. At least, one example of the practical results of thinking on the above lines is given in this paper.

The Bunsen and Teclu burner or a glass-blowing equipment is considered to be an essential equipment for any science laboratory. The spirit lamp cannot be a substitute for it, both from theoretical and from practical considerations. Unfortunately, however, very few schools can think of using these burners in their laboratories. The question of having a coal or kerosene-gas plant is out of the question even with the larger

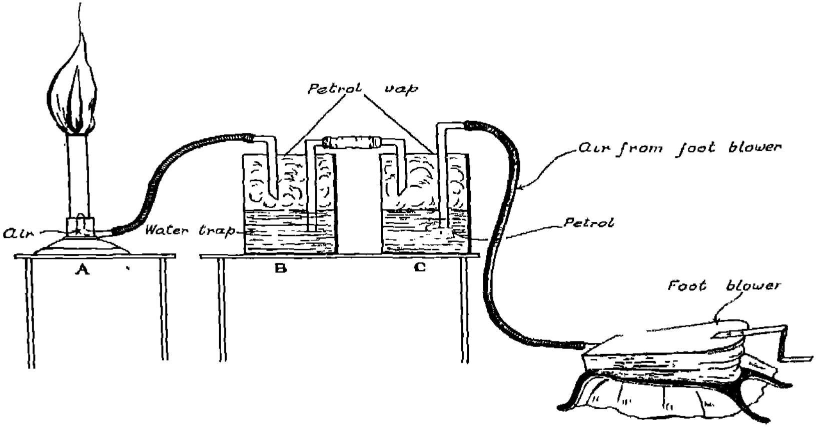

Fig. 1. Bunsen burner for the village

urban schools. Some may, perhaps, have the cheaper rotary petrol-gas generators. For the average rural secondary schools, the Bunsen flame is a dream that can never materialise.

A very cheap equipment to provide a working Bunsen, Teclu or glass-blowing flame was thought of even for the smallest rural school. The total cost of the equipment is expected not to exceed Rs. 50. One such equipment was exhibited in a science fair with complete success. The exhibit drew the admiration of scientists, educators and members of the public. A description and sketch of the apparatus is given here. Any average science workshop can fabricate the apparatus with the help of a village tinsmith.

HOME-MADE PETROL-GAS GENERATOR

Two tin cans B and C are prepared as shown in the sketch. The cans may be ordinary cans of ghee, mustard oil or baby-food with an approximate capacity of one litre. Two tin tubes made by rounding and soldering thin tin-sheets are inserted into each can through holes. One of these tubes must reach the bottom and the other about 1-2 inches below the top. A hole with a tight cap is provided for each to pour liquids in.

Assembly

Each can should be perfectly air-tight. This fact can be tested by attaching the longer tube to a foot-blower, closing the shorter tube with a rubber-tube and blowing hard while the can is put under a bucket of water. If air bubbles come out, locate the points and solder again to stop the leakage. Making the assembly perfectly air-tight is a necessary precondition for avoiding fire-hazards.

After the cans have been prepared as indicated, they are assembled as shown in Fig. 1. The connection between the water trap and the burner should be as long as possible. With a similar length of rubber tubing the foot-blower should be placed under the table with the burner for convenience in operation by a single person.

When the necessary assembly has been made, the cans B and C are opened and water and petrol poured respectively, till they are quarter full. Air is blown steadily with the foot-blower and the burner lighted. With a little practice a steady flame of the desired size can be obtained easily. It has been found that the flame thus produced is quite adequate for :

- demonstrating luminous and non-luminous Bunsen flames
- heating (to any desired degree)
- glass-blowing
- blow-pipe reduction of salt on charcoal.

Caution

1. The connections, cans, etc. must all be perfectly, air-tight.
2. The connecting tubes between the generator and the burner must be long.
3. The foot-blower should not be operated for long without lighting the burner.
4. The water-tank must be quarter-full with water.
5. Blowing should be steady and there should be no sucking back.
6. The petrol-tank must not be more than half-full.

Plan of a Teaching Unit—4

Earthworm is a Nocturnal Animal

G. Raju

Department of Science Education,
National Council of Educational Research and Training, Delhi

AN outline of the most important features of the earthworm in relation to its environment is developed and given below as a guidance for the teachers to plan their lesson along the lines of unit method of teaching science.

The earthworm is an object with which the children are quite familiar and the study of this simple creature carries a fund of scientific information. Since the object is such a familiar one for the children, this will inspire them to observe more and more and ask more questions. Since the life of these worms is so simple, the children can easily be guided to find the answers themselves, thus making the science concept more real.

In this outline an attempt is made on only one major concept, viz., *Earthworm is a nocturnal animal living in moist soil.* The other two concepts, viz, 1. *Its body parts are adapted to its food habits.* 2. *The activities of the earthworm benefit the farmer,* will be the extension of the knowledge and information gained from this topic. Therefore, these can easily be further planned and assigned to the children as a project work.

CONCEPT. Earthworm is a nocturnal animal living in moist soil. *(For Class VI)*

INTRODUCTION

1. *Motivation Through Observation*

Assist the children in setting up a wormery with a wooden box (30 × 30 × 15 cm) with a glass front, to enable them to observe and study the behaviour of the worms. In addition to this, museum jars or wide-mouthed jars or Horlicks bottles can also serve the purpose. Let them fill the bottles with alternate layers of sand, leaf mould, loam, leaves, etc. Let them collect the worms from the garden and introduce them into the containers. The soil should be periodically moistened.

Let them wrap some of the bottles with black paper or leave them in a dark room and let them place the rest of the bottles in a lighted room and observe the differences in behaviour of the worms in the two sets of bottles.

Display an enlarged coloured chart of the worm and, if possible, a model of the worm also. Encourage the children to handle the worm and measure its length, (when extended and contracted) count its segments and identify its various external parts with the guidance of the chart and model.

2. *Motivation Through Discussion*

Discuss the following questions which form the background of the topic. Encourage the participation of the students in the discussion.

1. What is a nocturnal animal?
2. What are the most common nocturnal animals?
3. How is the nocturnal habit beneficial to the animals?
4. What is the underlying meaning of the phrase, 'Even a worm will turn'.
5. Which are the localities wherein the earthworms occur in plenty?
6. In which of the areas is the earthworm considered as nuisance?

QUESTIONS AND PROBLEMS

1. Where do the earthworms live?
2. Why do the earthworms live in *moist soil?*
3. How do the earthworms breathe?
4. When do they come out of the burrow? Why?
5. (*a*) What is the nature of its body? (*b*) Do the earthworms have mouth?
6. How do they move from one place to another ?
7. (*a*) Do they have eyes and ears ? (*b*) How do they see and hear?

ACTIVITIES AND EXPERIENCES TO BE USED TO ANSWER THE QUESTIONS AND SOLVE THE PROBLEMS

1. *Where do the earthworms live?*

Select two regions of a garden. One of the regions should have dry soil and the other wet soil. Mark off a square area of 40 cm on the ground. Dig the soil to a depth of 20 cm of the square area marked Collect the soil separately in two containers Analyse the soil and count the number of worms found in each of the sample. In which of the two regions more number of worms are found for the same volume of the soil? What do you infer from this fact?

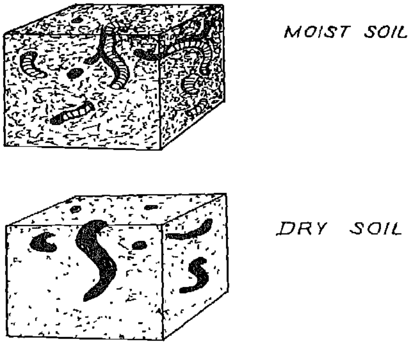

Fig. 1

Take a rectangular museum jar (height about 40 cm). Coat the inside of it with grease. Fill the bottom of it with small pebbles or gravel to a height of about 1 cm. Over it place 3-4 sheets of blotting paper, cut to the size of the mouth of the jar. Assemble the wash bottle as shown in the Fig. 2. Let the long glass tube pierce through the blotting paper and lie between the stones. Fill the jar with soil mixed with some manure. Introduce into them about 10-12 worms. Periodically blow air through the tube and thereby keep only the bottom layer of the soil moist, to a height of about 5-6 cm. After some days the soil of the upper layer will gradually dry leaving a layer of moist soil at the bottom. Remove the wash bottle and the tube. Take out the soil. If the

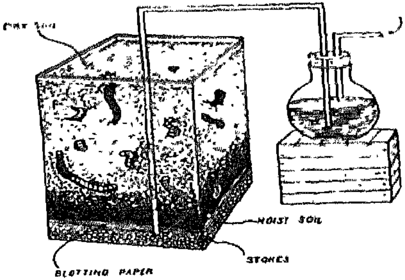

Fig. 2

whole block of the soil can be removed, it will be better. Examine and find out where the worms are all congregated. What is the reason for it?

Arrange another similar jar simultaneously, but without the wash bottle connection. After the worms are introduced, periodically sprinkle water and keep only the upper layer of soil moist. Allow the soil below to dry. Analyse and see where the worms are congregated in this case. What does this indicate?

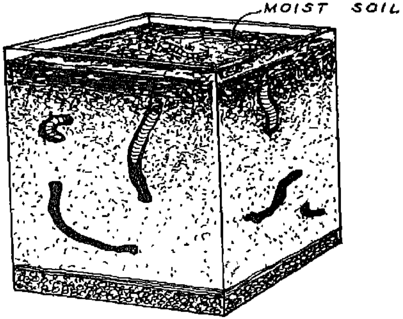

Fig. 3

During the dry summer months dig the garden in two or three places and observe the average depths at which the worms are found. Again dig the garden during the wet season (not when it rains and the soil is flooded) and find the average depth from where the worms begin to appear. Do you find any difference between the two. How do you explain this? From the above experiments, what do you conclude?

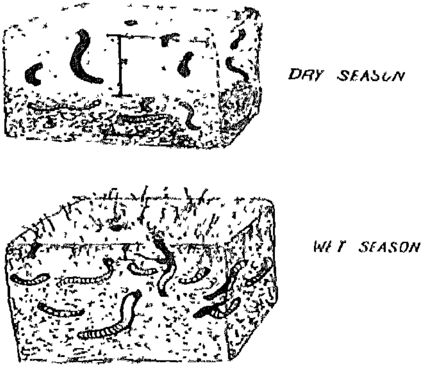

Fig. 4

2. *Why do the earthworms live in moist soil?*

Take a pair of wide-mouthed bottles (jam or Horlicks bottles). To one of the bottles add soil that has been dried well in the sun. To the other bottle add moist soil and moisten it periodically. Put some decaying leaves in both the bottles. Introduce about six earthworms in each bottle. Leave them for some days. In which bottle are the worms dead? Why? Infer that the worms die due to lack of water.

Why do the worms need water? Do we not need water for our living? How do we take water? Do the worms drink water like us? Repeat the experiment with the dry soil, with two worms, so that they can easily be handled. Daily take out the worms. Dip only their ends for sometime in water. Return them to the bottle. Handle them gently. Did the worms die after few days? What does this indicate?

3. *How do the worms breathe?*

Which part of the body of the worm is likely to come into contact with the moist soil? What will happen to its body in contact with the moist soil? Deduce that the body also becomes moist. Why should the body remain moist for the worm to live? Observe closely the skin of a worm? under a lens. How thin is its skin? Do you see the red colour of the blood of the worm through the skin? The blood containing carbon dioxide is brought to the skin. This is separated from the outside air containing oxygen. The skin separating these two is very thin and is kept moist. Which life process will take place under such a condition? Conclude that the worm breathes through its moist skin.

4. *When do they come out of their burrows? Why?*

How can you identify the burrows of the earthworms? Rear the worms in a wormery. Keep it outside and observe. Do you see anything by which you can identify the burrows of these worms. Visit the wormery during different periods of the day and night. When do you see them out of the burrows? Have you seen some birds feeding on these worms? What are the birds which feed on them? When do they feed on them?

Have you ever seen the earthworm crawling out of their burrows during the daytime? If so, when? Have you not seen them coming out of their burrows after heavy rains? Why? Take a bottle in which the worms are reared. Fill it with water. What do the worms do? Why?

5. (*a*) *What is the nature of its body?*

What is the shape of its body? Is it uniformly cylindrical? How are the rings arranged? How is the ringed body useful for its habit? Does it facilitate the twisting of the worm in different directions?

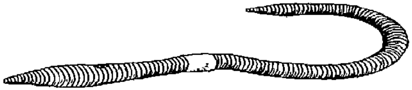

Fig. 5

Take a worm. Press it between the tips of two fingers. How do you feel? Is its body hard or soft? Press your body at the wrist and knee Why is it hard? Press at the arms. Why is it soft? Deduce that the muscular part is soft. Conclude that the earthworm has muscular body and, therefore, it is soft throughout its length.

Hold the two ends of a worm. Pull it slightly apart. What happens to its body? Leave it. Prick it with a pin. What happens to it now? What do you understand from this about the nature of its body?

5. *b. Do the earthworms have a mouth?*

Observe carefully the body of the worm. Is there a head? Do you find any difference between its head-end and tail-end? Lay the worm on the ground and watch it go. Which is its front end? Does the worm always move by its front end? Excite the worm by pricking it here and there by a pin. When it gets disturbed, watch its movement. Can you make the difference between its two ends now? If it moves forwards and backwards, how can you make out its front end? Do you see a saddle-like covering on the body of the worm? On which segment is it found? Is it present in all the worms? Watch a saddled worm moving normally. To which end of the worm does it lie nearer? Is there any difference between its two ends in their shape? Which one is more pointed?

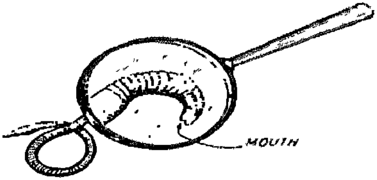

Fig. 6

Examine the pointed end with a less. Do you find an opening? Is such an opening present at the other end also? Do you find any difference between these two openings? Do you see a projection over its anterior opening?

6. *How do they move from one place to another?*

Hold an earthworm between your thumb and forefinger and observe how it slips away. What method does the worm use in doing so? Place an earthworm on a piece of paper, put your ear near to the paper and listen carefully. Do you hear anything? Can you hear a faint scratching sound? If its body is a smooth muscular one, how do you get such sound? Slowly pull the worm through your fingers from the tail end forward. How is its upper surface—smooth or rough? How is its under surface—smooth or rough? What causes the under surface rough? Examine the under-surface of the worms under the lens. What do you see? How many of them are present in each segment?

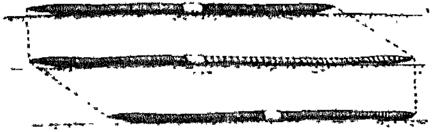

Fig. 7

Does the worm always move on its belly? Turn the worm over. Does it stay that way for long? Do you find any difference between the colours of the two sides?

Watch carefully the movements of the head-end and tail-end of the worm, when it crawls. Observe the position of its head-end in front of the saddle. When it is slowly extended forwards, observe the position of its tail end. Is it extended or contracted? Is it moving or stationary? Will not the tail-end also be drawn when the head end is elongated and drawn forward? What keeps tail-end in a stationary position? Deduce that the bristles firmly grip the ground and keep its tail-end in position. Next observe the position of its head-end. Is it stationary or moving? Its tail end? How will you explain now? Conclude that such alternating contraction and relaxation of the muscle and the gripping action of the bristles cause the movement of the worm.

7. *a. Do they have eyes and ears?*

Examine the head-end of the worm with a lens. Do you see eyes and ears? When it moves point a sharp needle towards it. Does it see and avoid it? What does it do? What does it indicate, if it comes, strikes against it and then responds? Blow a low whistle near it. Does it respond to it?

7. *b. How do they see and hear?*

How can they see, if they have no eyes? Recall that these are nocturnal in habit. How do they come out only during the nights, if they cannot see? How do they differentiate between day and night or light and dark? Keep an earthworm in a container with moist soil. Leave it for sometime in a dark room. Flash a very bright, fine beam of light suddenly over it. What does it do? What does it mean if it contracts? Conclude that the skin of the worm can feel the light.

How can they hear if they have no ears? Fill a broad tray with moist soil and decaying leaves. Put 20-30 worms in it. Leave the tray in a room on the floor near the wall. During the night, *tread softly* into the room with a torch light. Flash the light on the wall, and in the diffuse light count the number of worms that have come out of their burrows. Don't shine the light directly on the worms. After some time again enter the room, but this time with *loud foot steps.* Count the worms found outside their burrow as before. Repeat the count during different days and take the average. Is there any difference between the two counts? What is your inference about the reaction of the worms to the loud foot steps?

Keep a worm in a petri dish and leave it on a table. Blow the whistle loudly near it. Does it react to this? Place the dish with the worm on a piano, strike a loud note. What is its reaction now? Do you understand now, how the loud foot steps are heard by them? Conclude that the earthworm hears through the vibrations.

	Concepts	*Aims*
(1)	Earthworms live in moist soil.	To give them the first hand experience about the homes of animals.
(2)	The skin of the earthworms must be kept moist.	To make them appreciate the special adaptation of the living things to their environment.
	If the skin dries, they die.	
(3)	Earthworms breathe air through their moist skin.	,,
(4)	Earthworms normally come out of their burrows during night and remain outside till early morning.	To create in them the interest in the interrelationship between the living things and their environment. To increase their power of observation and reasoning.
	During the daytime, their skin gets dried up quickly.	,,
	They can avoid many enemies by coming out at night.	,,
	When rain water fills their burrows, they come out of them even during daytime.	,,
(5*a*)	Earthworms have a long cylindrical ringed muscular body which is elastic.	To make them appreciate the special adaptation of living things to their environment.
(5*b*)	Earthworms have a mouth at its head end which is pointed.	,,

(6) Earthworms move by the contraction and relaxation of the muscles, assisted by the bristles for gripping the ground.	To make them appreciate the very simple mechanism of locomotion.
(7*a*) Earthworms have no eyes and ears (*b*) The skin of the earthworm is sensitive to light They hear through the body.	To introduce them to new experiences which are different from the working mechanism of their own body.

CULMINATING ACTIVITIES

1. Ask a pupil to lie down on the ground. Let him plug his ears by inserting his fingers and close his eyes also. Ask another pupil to jump up and down the ground. Ask the pupil lying down to count the jumps. Let the pupil understand how he is able to count the jumps though his eyes and ears are closed. Let them learn that the earthwrorms also hear in this manner.

2. Take a cylindrical rubber band and place it on a soft wooden board. Fix the posterior half of the band with pins. Pull its anterior end forward. Fix now this end with pins and remove the pins from its posterior end. Repeat this several times to make the pupils understand how the earthworms move.

3. Arrange a field trip to a garden and to a pond. Encourage them to collect the different types of worm-like organisms which they find in the garden soil, on the plants and in the pond. Help them in identifying them. Let them rear the caterpillars collected from the plants and find for themselves as to why it cannot be called a true worm.

4. Keep the following animals in independent suitable cages, (*a*) centipede (*b*) praying mantis (*c*) grass hopper (*d*) crab (*e*) slug (*f*) frog (*g*) *Calotes* (*h*) robin (*i*) rat (*j*) mole. Let the pupils put one or two earthworms into these cages and find out which are the enemies of the earthworms.

NEW QUESTIONS

1. You should dig for the earthworms with garden a fork and not with shovel, why?
2. If the earthworms are gardeners' friend, the caterpillars are gardeners' foe, how?
3. Why do the earthworms occur in enormous number in manure heaps?
4. Why is the earthworm also called an angleworm?
5. Why do the birds find it difficult to pull the earthworms out of their burrows?

RELATION WITH OTHER SCHOOL SUBJECTS

1. Relate with the learning of ploughing and natural fertilizers in agriculture.
2. Relate craft in making models of the worm and drawing and sketching the diagram of the animal.

RESOURCES

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Classroom experiments

Recoil and Conservation of Momentum

THE effect of recoil can be demonstrated by the following experiment:

(a) Pour some water in a small bottle, and close it with a solid rubber stopper. Hang it horizontally by two light wires as shown in the Figure 1. Heat it cautiously. Watch when the stopper pops out. The bottle will recoil and some of the hot water will be spilled just below the support. Discuss the experiment in terms of Newton's law of motion and the law of conservation of momentum.

(b) Prepare a platform approximately 1" x4" x5". Suspend it by thin wires from four screw eyes in the corners as shown in the diagram. Attach a heavy rubber band to two nails near one end of the platform. Hold the middle of the rubber band

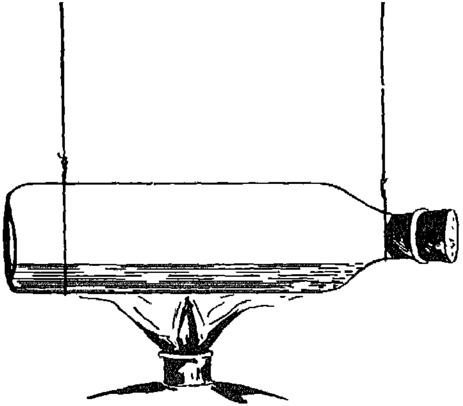


Fig. 1.

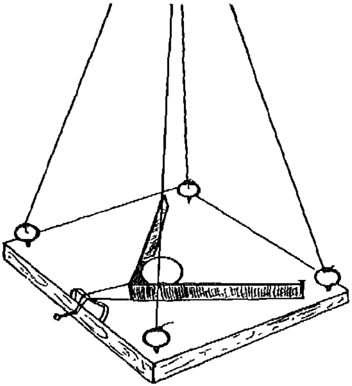


Fig. 2

back with a loop of string passing over a support made of a bent nail, and down to a nail on the opposite side of the swing. Place a heavy pendulum bob in the pocket formed by the rubber (Fig. 2). Burn the string by a flame held below the nail. Watch what happens. The ball will be shot out and the platform will recoil.

Use balls of different weights and compare the results of the experiment.

V.N. WANCHOO

WATER CULTURE AS A CLASS EXPERIMENT

Gas jars and milk bottles are too bulky and expensive to be used in large numbers for group experiments on water cultures. The method described below has several theoretical drawbacks but, in practice, gives good quantitative and qualitative results in three to four weeks and is suitable for groups of two or three students.

Wheat seedlings are germinated for about five days in a roll of moist cotton wool, groups of six seedlings of comparable size are selected, the fruits wraped in small plugs of cotton wool and placed in sterilized test-tubes of culture solution suitably blacked out with sleeves of dark paper. No aeration is necessary though the tubes must be kept topped up every day or so with distilled water.

The root system can be examined by sliding the test-tubes out of the paper sleeving and the total leaf length and root length be estimated and compared in each experiment (Fig. 3).

D.G. MACKEAN

(From *School Science Review* **44**: 403-404, 1963).

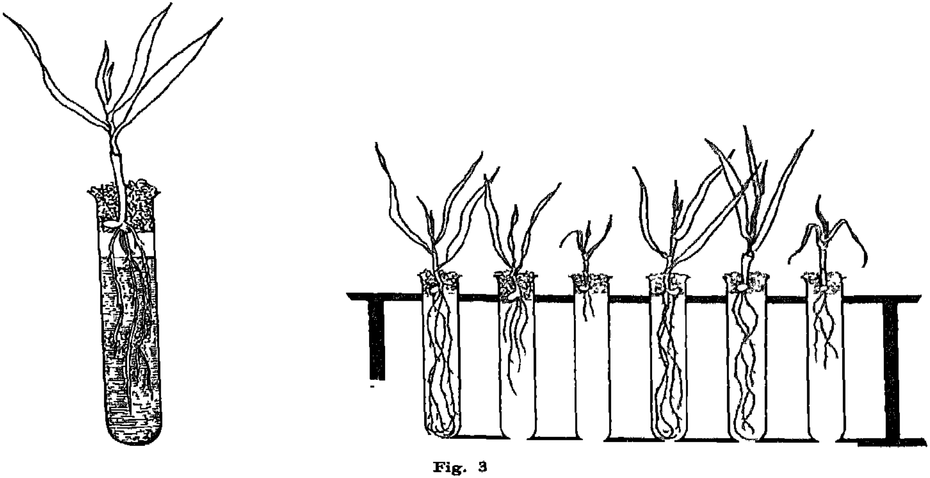


Fig. 3

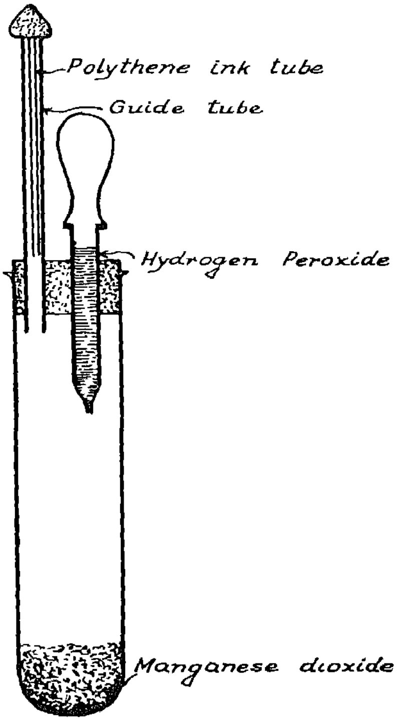


Fig 4

AN EXPERIMENT ILLUSTRATING CATALYSIS

The catalytic decomposition of hydrogen peroxide by manganese dioxide provides the basis for a rocket demonstration. The fountain-pen filler in the apparatus illustrated contains 10 volumes hydrogen peroxide, at the bottom of the boiling tube a quantity of manganese dioxide is placed. The 'rocket' is about 3in long and is part of the ink tube rejected from a ballpoint pen, the ballpoint being the head of the rocket. The glass tube guide is selected for size and water is used to lubricate the sides of the guide tube and rocket When the apparatus is assembled a slight squirt of the fountain pen filler causes enough heat and oxygen to be liberated to propel the rocket to the ceiling. The idea for this experiment came from Sweezey's book *Chemical Magic*, but the 'rocket' carved from balsa wood is replaced by the part of the rejected ballpoint pen (Fig. 4).

Another interesting experiment on cata-

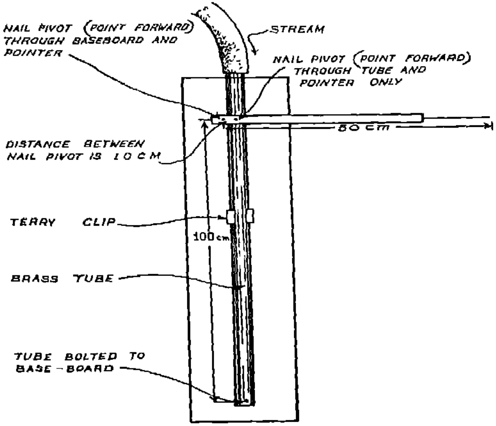

NAIL PIVOT (POINT FORWARD) THROUGH BASEBOARD AND POINTER
STREAM
NAIL PIVOT (POINT FORWARD) THROUGH TUBE AND POINTER ONLY
80 cm
DISTANCE BETWEEN NAIL PIVOT IS 1.0 CM
TERRY CLIP
100 cm
BRASS TUBE
TUBE BOLTED TO BASE-BOARD

Fig 5

lysis is to heat some platinized asbestos near the edge of a piece of wire gauze. The catalyst glows brightly and cools rapidly when the gas flame is extinguished. If the gas is turned on again glowing will recommence and it is possible by manipulation to light the gas above the gauze. This experiment is not difficult to perform and avoids the preparation of a catalyst which works directly from cold.

(*Ibid.* p. 413)

APPARATUS FOR COEFFICIENT OF LINEAR EXPANSION

The apparatus shown in Fig. 5 was built in one short session and requires very little skill in construction. The expansion of a brass tube 100 cm. long is indicated by a lever with a 50:1 ratio.

The expansion takes place quickly and is clearly visible from the back of a classroom. A typical expansion is 7.0 cm. for a temperature rise of 80° C. This yields 0.000018 per ° C for the coefficient of linear expansion. The pointer can be removed from one of the pivots and clipped on top of the tube for easy storage.

(*Ibid.* p. 450-451)

Science abroad

A Radio Telescope for the University of Sydney

M.I. Large
Sydney, Australia

THE discovery of intense radio stars in the sky took astronomers by surprise, for nothing in the light from the stars had led them to expect cosmic radio radiation.

With the discovery, the simple aerials that has made it became dignified by the name 'radio telescopes' and the new science of radio astronomy was established. It has developed rapidly as an important and vigorous branch of astronomy.

Surprise at the existence of radio stars turned almost to disbelief when their posi-

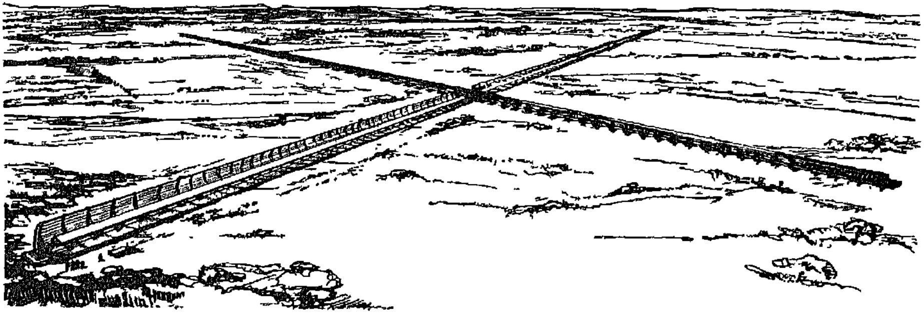


Fig. 32. A Radio Telescope

By courtesy of the Australian High Commission, New Delhi.

tions in the sky were measured, for they did not seem to coincide with any visible astronomical bodies. Here in the sky were powerful, yet invisible, transmitters of radio radiation.

One remarkable discovery followed another and we are now in the turmoil of a revolution in astronomical thought as profound as that which followed the construction of the large optical telescope earlier this century.

Then an astonished world learned to think and see beyond the stars of the Milky Way to the countless distant and fast receding 'island universes' which are known generally to astronomers as galaxies. Now we see by radio a new and fascinating sky populated with radio stars. A number of these inappropriately named objects - they are not ordinary stars—are galaxies, some near, some far, some at the greatest distances to which optical telescopes have penetrated. As for the majority, we don't know what they are. Are they galaxies at distance so great that the light from them is too feeble to be detected, holding in their radio signals cosmological information from the remotest parts of the universe, from the remotest past ? We do not know.

Further progress depends on making unambiguous identifications with optical objects. In this work the most pressing need is for new and bigger radio telescopes. To design and build such instruments is not easy. It is a challenge requiring skill, experience, a burning enthusiasm and financial resources.

This challenge is being met by the Chatterton Astronomy Department in the University of Sydney, Australia, which is building a new radio telescope on a level site among the hills of the Gourock Range 20 miles east of Canberra. Dr. B.Y. Mills, F.R.S., a Reader in the School of Physics, has designed the instrument, an advanced and sophisticated successor to the world-famous Mills Cross that he built near Sydney in 1954.

Much of the electronics of the radio telescope has been designed and is being built by the School of Electrical Engineering whose head, Professor W.N. Christiansen, is himself a radio astronomer of international repute.

The new instrument will be very different in appearance from the fully steerable paraboloid radio telescopes at Parkes in the State of New South Wales and at Jodrell Bank in England. It will take the form of a vast cross, the arms being cylindrical paraboloid reflectors one mile long and 40 ft. wide.

The reason for making the telescope this bizarre shape calls for some explanation. When astronomers and radio astronomers call for larger telescopes they are seeking to improve their vision of the universe in two ways. The amount of light or radio radiation gathered by the instrument increases in proportion to the total area of the lens or mirror. The ability to determine the size and shape of what it sees also depends on the dimensions of the telescope, this time in direct proportion to the diameter.

For optical astronomers, the most usual need is to gather as much light as possible. The best solution is to build a circular lens or mirror.

It does not follow that the same is true of radio astronomy. For the observations we are interested in at the university, the necessary measurements could be made only with a telescope nearly a mile across. The building of such an instrument would be out of the question if it also had to have the 'collecting area' of a mile-diameter reflector. Fortunately it does not. By building the instrument in the form of a cross the necessary diameter is realized. The width of arms is so chosen that the total area is adequate. Although the arms are very long, they are not unmanageably wide.

The instrument works in the following way The arm of the cross that is aligned east-west collects all the radio emission from a strip of the sky narrow in the east-west direction and wide in the north-south direction. The north-south arm similarly collects the radiation from a narrow strip of sky aligned east-west. The intersection of these two strips defines a fine point in the sky The electrical signals from the two are so combined that only the radiation from this region of intersection is recorded. This then is the direction in which the telescope is 'looking'

To change the direction in which a radio telescope looks, you usually move it physically This is unthinkable for the present instrument on account of its size. The elevation (angle from the horizon) in which the telescope looks is changed by purely electrical adjustments of the north-south arm It may seem strange that this is possible. The adjustments have the same effect as tilting the north-south arm about its east-west axis. For small angular movement, these adjustments of phase in the north-south arm are sufficient. For larger movements, the east-west arm must be altered also and it is tilted appropriately about its long axis

An advantage which follows from this electrical method of steering is that the telescope may be made to look in many directions at once. Initially there will be 11 beams (directions of looking) at a radio wavelength of 73 centimetres and three beams at a wavelength of 270 centimetres. No attempt is made to steer the telescope to the east or west, for the daily rotation of the earth sweeps these beams smoothly over the sky at a very convenient rate, building up a picture of the radio emission. The setting of the telescope may be altered quickly so that it will be possible to observe many different parts of the sky in a sinlge night's observation.

However, the most common use will be for the basic sky survey when the setting of the telescope will remain unchanged for most of each 24-hour day In one night, a narrow strip of the sky will be observed. On the following night a partially overlapping strip will be observed so that in due course the whole of the southern sky will be covered.

The building up of radio pictures of the sky in this way is rather like the way in which a television image is formed from the lines of the raster, but a thousand million times slower. During the observations a picture of the region being seen will be formed automatically on a modified, facsimile chart recorder. Isophotes, lines of constant radio brightness will be plotted to show the distribution of radio emission in the sky in exactly the same way that contour lines indicate heights on a map.

In addition to this chart record of the observations, there will also be a magnetic tape record of the results in numerical form. There will be about 1,000,000 numbers logged in this way during each night of operation. These data tapes will be read into the university's large electronic computor (an English Electric KDF9) for detailed analysis.

One of the main tasks of the telescope will be to obtain accurate positions, intensities and, where possible, angular sizes of up to 100,000 radio stars and statistical information on the distribution of a very much larger number. The identification of only a small fraction of these with optically observed galaxies would be of enormous importance in understanding the nature and evolution of the universe.

It will also be possible to prepare an extremely detailed map of the radio emission from the Milky Way. This will be done in a special survey soon after the instrument is completed. It offers exciting possibilities not only of seeing in great detail the parts of the galaxy that are hidden from optical view by the galactic dust, but also providing new information on the structure of the galaxy itself. A wealth of detail should be resolved in the Magellanic Clouds and in other nearby galaxies.

It has been mentioned that the telescope will operate simultaneously on two radio wavelengths. This is important because the way in which the radio power from astronomical bodies varies with wavelength is of great interest to astrophysicists. In this connection it is worth pointing out that the large steerable radio telescope at Parkes is ideal for observations at shorter wavelengths than those used by the new cross so that the two instruments will play complementary roles in elucidating the mysteries of cosmic radio radiation. Indeed the range of studies that will be possible with the new instrument will be tremendous. If the last few years of radio astronomy are a reasonable guide, we may expect new lines of investigation to be opened up by the new telescope.

It is planned to operate the telescope on a regular basis of observing for 20 hours every day, except when adverse weather conditions such as high winds or thunderstorms prevent it. Usually no observations will be made for two hours each side of noon, when radiation from the sun would seriously interfere with the results. The break will be used for carrying out electrical tests to ensure that the entire instrument is correctly adjusted. When, however, the sun itself is the subject of study, observations will necessarily be made at noon.

Only a small operating staff will be required. In addition to a resident mechanic two or three members of the scientific and technical staff will probably be staying at the site when observations are in progress. Their immediate job will be to change the paper charts and magnetic tapes daily, and to carry out the routine checks. Although the instrument has been designed so that operation from one day to the next does not depend on continuous surveillance by the staff, in the early days of operation none of the scientists involved will be able to resist staying awake at night to watch the output appear on the chart and speculate on its significance. This is a universal occupational weakness of radio astronomers.

No account of a new radio telescope would be complete without putting it in its place among other radio telescopes in the world. This is complicated by the fact that each instrument is specifically designed for a particular kind of observation. The only comparable instruments are the new 'aperture synthesis' telescope that Professor Ryle is building in Cambridge and the proposed 'benelux Cross'. Both these instruments have their individual merits, and will have a performance similar to that of our new cross. In the southern sky, the University of Sydney's cross telescope will be unique.

The work on the isolated plains at the head of the Molonglo River near Canberra proceeds rapidly. The first stage of the steel work is almost complete, and it will not be long before several hundred thousand square feet of 1 inch x ½ inch galvanised mesh are being stretched into position on the east-west arm. Radio astronomers have been accused of lack of humility in thinking that a few acres of chicken wire strung up on a field will ever solve the problems of the universe That may well be so, but it is difficult to visit this remote site and watch the instrument taking shape without feeling that this strange engine might after all be in close communion with nature

TECHNICAL DETAILS

NORTH-SOUTH ARM

Length	5200 ft , 179 29ft. modules.
Width	42 ft.
Area	218,000 sq. ft.
Total number of dipoles	4296 or 24 per module (for 408 Mc/s).
Total number of amplifiers	179 or 1 per module (for 408 Mc/s).
Method of steering	Electrical phasing or dipoles.

EAST-WEST ARM

Length	5200 ft. 176 29ft. modules
Width	38 ft.
Area	194,000 sq. ft.
Total number of dipoles	2816 or 16 per module (at 408 Mc/s).
Total number of amplifiers	22 (at 408 Mc/s).
Method of steering	Each module mechanically tilted
Regions of sky accessible	55° north or south of the zenith, *i.e.*, all declinations from + 20° to —90°.
Frequencies of operation	408 Mc/s ± 1.3 Mc/s (73.5 cm wavelenth) 111 5 Mc/s ± . 13 Mc/s (270 cm wavelength).
Beamwidths to half power (angular detail resolvable)	2.8 min of arc at 408 Mc/s. 10 min of arc at 111.5 Mc/s.
Total weight of steel work	600 tons

Fistfuls of Power for the Heavens and Earth

Bruno Friedman

Miniature nuclear power packages are being developed to generate electricity for satellites and spacecraft, with many potential applications down on earth. Already such packages are being used in robot weather stations and in ship navigation devices.

THERE is a conception of mighty Zeus, King of the Gods, bestriding the heavens with a fistful of lightning bolts and hurling them towards the Earth. In 1961 this picture acquired a form of modern-day reality, for in June and November of that year, two United States navigation satellites, Transit 4-A and Transit 4-B, were shot into orbit. These statellites, the first in what will eventually be a series of navigation satellites for the U.S. Navy, designed to aid ships to pinpoint their locations on the seas of the world, each contained a remarkable little electric generator, using the power of the atom. This was a landmark in man's developing technology, for it marked his first use of nuclear power in space.

The generators, named SNAP-3, each weigh merely two kilogrammes and are barely the size of a grapefruit. The electricity they produce, over their lifespan of five years, is equivalent to that turned out by five tons of automobile storage batteries It is used to operate instruments and small radio transmitters.

Truly, the mighty atom harnessed to make electricity in the heavens is the virtual image of Zeus flinging his lightning bolts to earth.

The SNAP-3 electric generators are but the first in a numerous series of compact power generators intended originally to provide power for weather and other-purpose satellites, space stations, spacecraft, and even colonies of spacemen on the moon and in the more distant future—on other planets. They are all remarkable for the production of comparatively large amounts of power in very compact volume over a very long period of time and with very little or no supervision by humans.

The SNAP series of nuclear power generators—taking its name from Systems for Nuclear Auxiliary Power—is being developed under the Atomic Energy Commission of the United States. While originally conceived for space use, their concept has been broadened to include earth-bound applications. They range in power output from the grapefruit-sized SNAP-3's three watts to a giant which is expected to produce about 1,000 kilowatts. The latter will be used in deep space missions, not merely to provide power to sustain life and equipment aboard the spacecraft, but mainly to provide thrust.

Two Types of SNAP Generators

There are actually two types of SNAP nuclear power generators, each based on a completely different technology. Consider SNAP-3. This active little grapefruit of power represents one type, all of whose members have odd number

UNESCO Features. No. 421—August 9, 1963.

designations. It is based on the conversion of heat produced by decaying radioactive elements directly into electricity, without any moving parts. These radioactive elements may be extracted from the wastes of nuclear power plants or may be prepared by exposing a selected metal to intense radioactivity in a nuclear reactor core.

A small pellet of Plutonium-238, surrounded by a housing, is the power source in SNAP-3. Other radioactive metals are used in other members of this series of generators, called 'atomic batteries' or 'radioactive isotope generators'.

SNAP-7 uses Strontium-90 as the radioactive fuel. Various SNAP-7 models, which put out either 5 or 30 watts of power, are now being used or will shortly be used by the United States Coast Guard and Navy in navigational aids and automatic weather stations set up in the Arctic and Antarctic, as well as in a floating weather station. The navigational aids are such items as a channel buoy, a land-based navigation light, and an experimental navigational beacon.

Another reactor, the SNAP-11, uses Curium-242 and is expected to provide about 20 watts of power continuously for 90-day missions to the moon. It weighs only 30 lb. including the shell around the fuel element and will also provide heat to help combat the bitterly cold lunar night.

Yet other SNAP generators using radioisotopes are in the process of development. Their compactness and their safety, which has been fully tested in numerous ways, plus their continuous unsupervised, trouble-free operation will make them ideal for many uses on our planet.

SNAP Generators in Unattended Instruments

It is possible, for example, to foresee the use of such generators in unmanned instruments which will automatically report information on the patterns of flood conditions in rivers, in unmanned seismological stations and in various other geological devices to help in the understanding of our planet, particularly in Africa and South America where vast areas are still largely mysteries. They could serve, too, as forest-fire warning stations.

Potentially, radioisotope generators could be very inexpensive. It has been stated, for example, that the cost of the components of SNAP-3, exclusive of the fuel pellet, can be brought down to $200 on a mass-production basis. The problem is the cost of the radioactive fuel. It is possible, however, that economical ways of recovering fuels from the radioactive wastes produced by nuclear power stations may be developed, though the problem is a difficult one.

Baby Nuclear Reactors for Large Quantities of Power

For large amounts of power far beyond that which can be provided by SNAP-3 and its similars, another series of SNAP power generators is being developed. All of these are designated by even numbers. They are miniature nuclear reactors and they operate in the same way as the giant nuclear power stations being built in many countries to produce electricity for homes and industry. The down-scaling of nuclear reactors to a very compact size is an outstanding technological achievement. Prototypes of these —comparatively—tiny reactors have proved themselves in ground tests since 1959. Starting in late 1963 and through 1965, the first flying versions of the several different models will be shot aloft in satellites and space probes.

The principle of a reactor is quite different from that of a radioactive isotope generator. Whereas in a generator like SNAP-3 the heat that is converted to electricity results from the spontaneous decomposition of atoms, in a reactor like SNAP-2 the decomposition of atoms is *stimulated*. As one radioactive atom decomposes (or fissions), it releases neutrons which strike the nuclei of other atoms and stimulate their fissioning, these in turn releasing neutrons which can continue the chain reaction.

Reactors in this series will provide long-lived power ranging upwards to thousands of kilowatts, with weights of the reactors plus shielding ranging from hundreds to thousands of kilogrammes. Their fuel is, generally, Uranium-235.

The smallest in the series, the SNAP-10A and the SNAP-2, will generate 500 and 3000 watts, respectively. They will provide the electric power needed for operating equipment and instruments aboard spacecraft. Larger models like the SNAP-8, which will develop 30 kilowatts, will be used to provide thrust to move the craft through space when man starts travelling outward to the planets. The same thing is true of the very large, 1,000-kilowatt SNAP-50. Here we project into a more distant future, for SNAP-50 is visualized for spacecraft carrying 20 or more men.

Power Stations for Remote Areas

Compact reactors such as these have immediately foreseeable uses as power stations in remote areas where the cost of erecting conventional power stations and of transporting coal or oil to these stations is prohibitive. In the polar regions and in deep jungle areas far away from transportation where important scientific or industrial work must be done the installation of such reactors seems specifically indicated.

Another immediately foreseeable use is in communications satellites capable of transmitting radio and television programmes directly to our homes. Such satellites would be far superior to Telstar, the first satellite used for linking continents (North America and Europe) by television.

Telstar is merely a very low power relay station. It can do nothing more than retransmit a television signal sent out from a transmitter on one continent to a transmitter on another continent.

Reactor-powered communications satellites will have sufficient power, measured in kilowatts, to broadcast the television signal directly into homes, without the intermediary of a ground-based transmitter.

Before such communications uses can be made of the compact SNAP reactors, the advanced satellite and reactor technologies required must be further developed. How soon? Ten Years? Perhaps. By then the same television programmes may be viewed, as an unremarkable event, by peoples of the various continents.

New Australian Instruments to Probe Ionosphere

Patrick Davidson
Sydney, Australia

TWO radio experts in the University of Sydney have developed a most versatile instrument designed to study the ionosphere. Their 'small package' invention has a variety of functions.

It is a tool for fundamental research into the constitution of the ionosphere, an indicator of suitable radio frequencies for transmission circuits, and a camera that produces an immediate picture of the

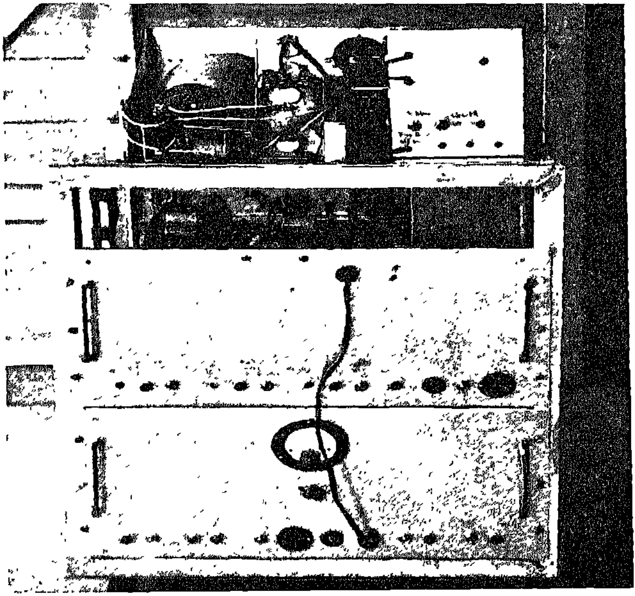


Fig. 1 New Australian Instrument to probe Ionosphere

By the courtesy of the Australian High Commission, New Delhi

upper atmosphere at a given height. As part of this latter function, it shows the highest frequency at which short-wave transmitters can send signals at that time.

The instrument, a neat and tidy electronic device, is versatile, compact, light in weight and cheap to make. It measures 22in. in breadth by 22in. in depth by 34in in height and weighs 270 lb.

The Weapons Research Establishment at Salisbury (South Australia) has let the contract for its production and expects its price on the market to be about £A5000.

The inventors of the new Australian instrument are Mr. Lloyd Heisler and Mr. Les Wilson, officers of Australia's Commonwealth Scientific and Industrial Research Organisation attached to the Radio Research Board Laboratory in the Department of Electrical Engineering at the University of Sydney. They have called their device an 'ionosonde' but its more formal name is 'automatic variable frequency ionosphere recorder'.

The university has patented the instrument, which will appear on the market early in 1964.

The ionosphere is an area of the earth's upper atmosphere starting at about 60 miles above the surface and continuing out for some 200 miles. Ultra-violet rays from the sun electrically charge the particles in this broad belt to form ions—electrically charged atoms. But for the presence of the ionosphere, short-wave radio transmissions would travel straight out into space from their points of origin. Short-wave messages are possible only because the signals bounce back from the ionosphere. At times of solar activity, magnetic storms often interfere with radio communications.

Mr. Heisler said that the primary function of the ionosonde was to carry out research into the ionosphere. Its other facilities were by-products of this function.

'One of the qualities of the instrument,' he added, 'is that it electronically scans the frequency range. Other equipment with a similar purpose has to depend on cumbersome mechanical means of scanning. For example, other equipment covers the frequency range of from one to 20 megacycles in a sweep time of 30 seconds. The ionosonde covers the same range in two seconds. This is particularly valuable for the study of rapid changes in the ionosphere. We did not previously even suspect some of the changes that we have since observed.

'The ionosonde measures the electron density at a given height in the atmosphere. The touch of a lever enables it to select any chosen frequency range between one and 20 megacycles for its frequency sweep. We can also consider the instrument as an ionoscope. By touching a button, an investigator can get an immediate picture of the ionosphere over a given frequency and height range, displayed on a television screen built into the equipment.

'As well as producing pictures for fundamental research, this facility also indicates the highest frequency at which shortwave radio messages can be transmitted at that time. We have added a second screen to the equipment to display pictures which an attached camera will photograph in series on 35mm film.'

Young folks corner

Scientists You Should Know

ANTONI VAN LEEUWENHOEK (1632-1723)

PIONEER OF MICROCOSMOS

THE name of Antoni van Leeuwenhoek needs no introduction among biologists or bacteriologists. He was the man who discovered the micro-organisms and from whose house news reached the world of the discovery of spermatozoa—the male reproductive cells. Van Leeuwenhoek does not appear to have been in any way destined for immortality. Born in the town of Delft, on October 24, 1632, he was the son of a basketmaker. This was, perhaps, not quite such a modest beginning as may appear at first sight; we must not overlook the fact that the famous Delft chinaware of those days was sent all over the world packed in baskets! His mother was the daughter of a brewer and was related to a line of City Fathers. The young Antoni was destined to enter the cloth trade, for which he received training in Amsterdam. It was undoubtedly there that he learned to use a magnifying glass—the means by which the threads in the woven material were counted. In 1654 he set up in business in his home town. In those days, Delft was one of the largest towns in Holland; it had its own port and was a centre of considerable trade. Two old bills which have been preserved indicate that Van Leeuwenhoek began as a haberdasher, but in 1660 he was appointed Usher to the Aldermen of the town. Shortly afterwards he took on the additional office of Municipal Wine-gauger in which he was responsible for seeing to it that the wine vats were of the correct size. He also took an examination as Land Surveyor.

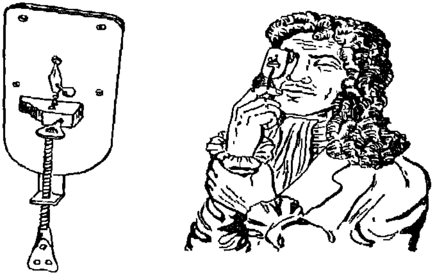


Fig. 1 Leeuwenhoek's magnifying glass

As far as can be ascertained, Van Leeuwenhoek did not commence microscopic research until he was about 40 years old. Certainly he was not the inventor of the microscope (as is often stated) but he was one of the first to make intensive use of that instrument. The pioneers in microscopic research were headed by the Italian scientist Marcelli Malpighi, the Englishman Robert Hooke and a countryman of Van Leeuwenhoek, Jan Swammerdam. Their publications were read mainly in scientific circles whereas the works subsequently produced by Van Leeuwenhoek were consumed in a far wider circle.

In the beginning, Van Leeuwenhoek had no intention of making the results of his observations known but a fellow townsman Reinier de Graff, an anatomist and medical practitioner, succeeded in persuading him to pass on the information on his findings to the Royal Society in London. Van Leeuwenhoek had no knowledge of Latin nor, indeed, any foreign language and thus the scientists in London were obliged to have his letters translated out of the Dutch language. They were interested in the contents and, in fact, asked him to send further reports on his observations This was the signal for a series of more than 250 letters covering half a century, from 1673 to 1723, the contents of which created amazement and admiration all over the world

Van Leeuwenhoek made his own microscopes, tiny little instruments no larger than a matchbox and consisting mainly of two metal plates riveted together with a small opening containing a single, ground lens about the size of a pinhead. Just how he ground his lenses we do not know; that is one of the secrets which died with him. We do know, however, that he made several hundred of these tiny microscopes, of which only very few still exist. These include specimens now in the National Museum for the History of Science in Leiden and the University Museum in Utrecht. The latter is the strongest and has a magnifying power of 270.

But the manufacture of these instruments was not Van Leeuwenhoek's greatest problem; that was to make a good preparation and, having done so, to fix it in position in the microscope. To this end, the instruments were fitted with a small needle which could be brought into position exactly in front of the lens with the aid of two small screws. For spoiled, modern people like us it is incomprehensible that Van Leeuwenhoek could have made so many, and such accurate, observations with his primitive microscopes and have penetrated so deeply into the mysteries of Nature. So little was known of the 'world in the microscope' that every slide which he placed under his lens produced new—and often surprising—information. He combined skill, ingenuity and endless patience in examining everything which came into his hands. In the field of zoology alone it has been established that his researches involved more than 200 animal species.

But Van Leeuwenhoek investigated many other things, for example milk and butter, the growth of hair and nails; bones, teeth and tusks; the skin and muscles, the eyes and nerves. His drawings of striated muscle fibres and of the cell nucleus in the red blood corpuscles of fish deserve great admiration. He examined the structure and operation of the eyes of insects. It was he who discovered that eels had scales; this gave rise to the assumption that the age of a fish can be ascertained by the number of scale layers, just as the age of a tree can be seen from the number of rings in the trunk. A comparison of Van Leeuwenhoek's drawings of the anatomy of timber with those of his predecessors Malpighi and Grew will show that he had had a much clearer insight into the structure. His descriptions and illustrations were the best in existence prior to the 19th Century. He devoted considerable attention to other vegetable tissues too, mainly fruits and seeds of which he closely studied the embryos. He also studied plant galls and the behaviour of the ichneumon fly, and noted that these parasites were capable of developing only in specific types of host. Van Leeuwenhoek's interest was centred in the biological field. His medical research was only fragmentary and yet one of his discoveries was destined to be of inestimable value to medical science; this was the discovery of micro-organisms. Although he described these in a letter to the Royal Society as far back as 1674, neither he nor the members of that worthy society realized at the time that a whole new world was about to open. Only when, in October 1676, Van Leeuwenhoek despatched a long letter containing information on Rotifera (wheeled animalcules), Protozoa (single celled animals) and bacteria was the real significance recognized.

As a basis for his calculations, Van Leeuwenhoek used the comparison with millet seeds and grains of sand; the result was that the smallest 'beings' which he observed (bacteria are now regarded as part of the vegetable world) were one-millionth of the size in volume of the mites which were generally regarded as the smallest in existence. In the beginning the experts in London were unable to believe the results of these observations but the stream of letters from Van Leeuwenhoek continued to pour into the Society's headquarters. More than a year passed before, in November 1677, these could be verified. Van Leeuwenhoek immediately became the 'man of the moment' and even the King of England commanded a demonstration of the incredible animalcules which had revealed themselves under the Dutch scientist's lens.

Van Leeuwenhoek did not rest on his laurels. Hard on the heels of his reports on the discovery of bacteria came his letter indicating that he had discovered the existence of spermatozoa. A young man by the name of Ham who was studying in Leiden had shown them to him; and once he had seen them for himself, Van Leeuwenhoek was immediately convinced that what he saw was the embryo of animal life. In the ensuring years he succeeded in identifying these embryos in dogs and human beings, but that was not all. He also confirmed their existence in very tiny insects and animals such as lice, fleas and mites. These discoveries convinced him that these minute beings did not just 'happen' or emerge from dead matter but that they reproduce in the same way as do higher animal species. The battle against the concept of spontaneous generation runs like a scarlet threat through his subsequent letters. He also fought a battle on another front in regard to the theory of reproduction; shortly before Van Leeuwenhoek's discovery, his fellow townsman Reinier de Graaf had discovered the existence of the ovarian follicle in mammals. This was named after him. A lengthy argument ensued between the 'ovists' who regarded the egg as the nucleus of life and the 'animalculists' who, headed by Van Leeuwenhoek, stuck to the theory that the spermatozoa were the material beginnings of young organisms. This argument was indeed lengthy, it took two centuries before it was established that the ovary cell and the spermatozoa perform equally vital roles in the process of reproduction.

It is not easy to sum up the position

which Van Leeuwenhoek occupied in the history of science. His discoveries were the foundation stones of research in many fields. But he did much more. He was never afraid to couple speculation to the reports of his observations. This was tantamount to a confession that his hypotheses might not stand up to further investigation. Indeed he often withdrew an opinion which he had expressed earlier. But because he was imbued with the courage of the simple-hearted and allowed his speculations to be discussed in the open, he succeeded in putting minds and pens to work. The Royal Society published his letters—or extracts from them—in *Philosophical Transactions*, one of the most widely read scientific publications of the day. This publicity turned Van Leeuwenhoek from an isolated amateur into a scientist of world repute; into one of the most famous figures of the period in fact.

Rulers and scientists attended his laboratory clamouring for a demonstration of his discoveries. With Van Leeuwenhoek's death in 1723 at the age of 90, the city of Delft mourned one of its greatest citizens of all times.

Test your knowledge

What is light ?

The modern view is that light is a form of energy travelling at a constant velocity. The *quanta* of light behave both as tiny material particles and as waves. This contradictory character cannot be understood easily. The terms can be reconciled by the use of the mathematical discipline of Quantum Mechanics. Visible light is merely a small portion of the total electromagnetic radiation spread over a range of wave lengths. The individual *quanta* or packages of light are called photons.

What does Einstein's equation $E = MC^2$ *mean ?*

It means that if matter having a mass M is converted into energy, the amount of energy (E) thus derived will be equal to the mass times the square of the velocity of light which is 300 million metres per second. The square of the velocity of light is enormous and hence the energy available even in a small particle of matter is extremely large. If M is measured in kilogrammes and C in metres per second, the value of E is in joules. Nuclear reactors convert matter into energy. It is more difficult to change energy back into matter.

What is the principle of the vacuum tube ?

A sealed bulb of glass is exhausted of air to a high degree. The filament inside is made to glow by a current fed into it through the tube base. Near the filament is a *plate* of metal and between the two a *grid* or metal screen. All three are insulated from one another. A high direct current voltage is applied between the filament and the plate by a battery on the outside, the plate being positive. When the filament is heated a stream of electrons flows from it to the plate. This stream can be controlled—allowed to pass, slowed down or cut off entirely—by very small voltage variations on the grid. It always flows in one direction towards the plate. Thus the tube is a one-way 'valve'— a name it still carries in England. This name was given to it by Sir J J. Thomson who showed that the emitted particles are electrons.

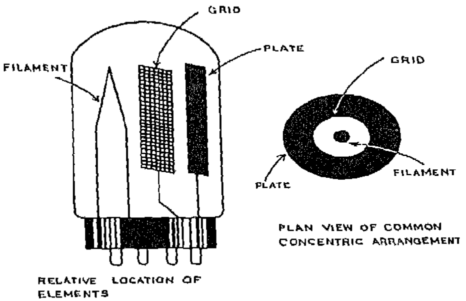

GRID
PLATE
FILAMENT
GRID
FILAMENT
PLATE
PLAN VIEW OF COMMON CONCENTRIC ARRANGEMENT
RELATIVE LOCATION OF ELEMENTS

Fig. 1. Vacuum tube

What is cholesterol ?

Chemically it is a fatty alcohol naturally occurring in the bile. When produced in excess (by eating too much fat or sugar) it is believed to form a hard, insoluble deposit on the inner walls of the blood vessels. This narrows them down, raising their resistance to flow of blood and hence raising the blood pressure. Excess cholesterol is a major cause of hardening of arteries and thus also a major cause of death.

The excess can be controlled by avoiding saturated fats and by drug therapy. The common dietary fats are essential to body motabolism, in moderation.

Which is the most famous of all comets ?

The most well known comet is Halley's comet. This appeared in 1910 and is due to appear again in 1985 or 1986. This comet has been seen at intervals of about 76 years ever since 240 B.C.

Has the Earth ever come in the path of Halley's comet ?

In 1910, it was believed that the earth would pass through the tail of Halley's comet which was supposed to contain cyanogen, a poisonous gas, but the greater density of Earth's atmosphere seems to have protected the inhabitants from any harm.

Is twilight longer in the temperate or torrid zone ?

Twilight lasts sometime after sunset in the evening and just before sunrise in the morning. Morning twilight begins when the sun reaches a point 18° below its rising horizon; and it lasts till the sun reaches a point 18° below its setting horizon at night. In the torrid zone, the sun approaches the horizon at an angle nearer the 90° than it does in a temperate zone. Hence the path of sun from 18° below horizon is more direct and shorter. For that reason, twilight is always shorter in the torrid zone than in the temperate zones.

Do sponges have skeletons ?

The tissues of the sponges require some support as do the tissues of other animals. Such a support exists in sponges in the form of fine scaffolding made up either of numerous interlocking *spicules*, or crystalline rods which are either calcareous or siliceous. Both these may be absent and the skeleton may be merely a tough fabric of horny fibres. Skeletons of sponges with siliceous spicules are known as glass sponges and are inhabitants of deep, still waters. They exhibit remarkable beauty. The commercial sponges, that are known as bath sponge, are skeletons of the horny type. Living sponges are black and slimy and after some treatment and bleaching they are sold as both sponges.

Why is time reckoned in hours, minutes and seconds instead of in decimals ?

About 3000 years ago, the Babylonians used the sexagesimal system of numbering, based upon a multiplication of 6, instead of the decimal system which we now use. The circle was divided into 60 x 6=360 degrees. Each degree was divided into 60 parts and each of the latter in turn into 60. The first part came to be known as 'minutes' and the second small part 'second'. These are derived from the original Latin names given them by Ptolemy.

The round face of the clock led man to divide the hours into minutes and the second small division into seconds.

When was radium discovered ?

The element was shown to be existing by Pierre Curie, Marie Curie and G. Bemont in 1898. Mme Curie isolated the pure salt of radium in 1902 and in 1910 she, along with A. Debierne succeeded in producing radium metal.

What is a radium dial ?

Watches, clocks and metres that have dials to be read in the dark are treated with a luminescent paint made from zinc sulphide in which is incorporated a very small concentration of a radium salt.

What is radon ?

When uranium-238 decays to lead-206 an intermediate product in the form of gas is formed and this is called radon. It is highly penetrating and has wished the prospector into thinking that it is actually coming from a uranium deposit, which may be some distance away buried deeply beneath the soil.

Science notes

PORTABLE TELEVISION RECORDER REGISTERS SIGHT AND SOUND

AN easy-to-operate portable television recorder weighing only 75 lb. (34 kilogrammes) can register 96 minutes of sight and sound on tape for immediate or later reproduction.

The compact machine, which can be set up and operated almost as easily as an ordinary voice recorder, is about the size of an ordinary suitcase. Together with the microphone and camera needed to make recordings, it fits easily in the rear seat of even the smallest cars.

The machine, which makes a permanent record of television programmes, already is in use in schools, colleges, industrial firms and government agencies. Medical colleges are using it to record closed-circuit telecasts of surgical techniques in the operating room for later showing at classroom sessions and medical group meetings.

Industrial firms which monitor manufacturing processes by television are using the new machine to introduce new products and techniques to sales forces and dealers. Space vehicle researchers and airplane designers use it to make permanent records of television pictures made in wind tunnels and of other laboratory tests.

Only a small fraction of the size, weight and cost of studio-type television recorders, the fully transistorized model was designed and is manufactured by the Precision Instrument Company of Palo Alto, California.

The easy-to-thread tape moves around two recording heads - one for sight and one for sound - at a relatively slow rate of 7½ inches (19 centimetres) per second, thus reducing usage of tape by 25 per cent or more compared to the larger TV recorders. The tape may be played back immediately after recording or years later. It can be used 100 times or more and can be erased for reuse if desired.

By the courtesy of U.S.I.S. New Delhi.

ELECTRONS KEEP SAUSAGES FRESH

Pork sausages that have been exposed to a beam of electrons out of contact with air, then stored at 1°C in an air-free environment, are likely to stay fresh for nine weeks - three to four times as long as unirradiated sausages stored in the same way. And their taste and smell remain practically unchanged. These are the main conclusions reached by B. Coleby and three of his colleagues after 2 years of work at the low temperature Research Station, Cambridge. From their work it is clear that low irradiation can provide freedom during distribution and could be of value to the housewife, provided a packaging material can be found that will keep out air and moisture (the latter causes loss of bloom).

From *New Scientist* 17(32) : 4067 February 21, 1963)

CHANGING VICTORIA'S LEAVING CERTIFICATE

From 1964 the Schools Leaving Certificate in the Australian State of Victoria will be a subject certificate and not a group certificate. Students sitting for Leaving Certificate examinations will receive certificates crediting them with the subject in which they have passed. Until now they have received a certificate only if they have passed in at least four subjects including English, a 'humanity' and a branch of mathematics or science. To matriculate into a university, students will still be required to pass in five subjects with group requirements. 'Increasing numbers of boys and girls are staying at school beyond the Intermediate Certificate Year', the chairman of the Schools Board, Professor W.H. Frederick said. 'For many of these the task of meeting present requirements at the present examinations is too great. The prospect of receiving credit on a certificate for any subject passed will be an encouragement and a satisfaction.'

By courtesy: The Australian High Commission, New Delhi.

NEW CHEMICAL DEVELOPED TO COMBAT DISEASE

British scientists who have been studying bilharziasis—one of the major parasitic diseases—have developed chemicals which they believe will make a real contribution towards combating the disease.

At the Woodstock Agricultural Research Centre of Shell Research Ltd., in Kent, southern England, scientists have spent several years breeding and studying some of the species of snails which are involved in the transmission of the disease, which afflicts an estimated 150,000,000 people in Asia, Africa, the Caribbean, South America, and the Eastern Mediterranean.

Samples of chemicals found by Shell scientists which will kill the snails while leaving nearly unharmed other forms of animal and plant life are now being tested by health experts in 11 countries from Africa to Japan.

'Preliminary reports from some of these tests indicate that Shell may be able to make a significant contribution to the control of snails, and hence to one of the most important parasitic diseases of the present time', reports Shell International Petroleum Co. Ltd., in London.

By courtesy. The British Information Services, New Delhi.

HOOKWORM DISEASES FACE ERADICATION BY NEW COMPOUND

Diseases caused by hookworm, transmitted by dogs to humans, face possible eradication through a new compound called DNP—Disophenol. Still a major health problem in many parts of the world, diseases resulting from blood contamination by hookworms can result in anaemia, emaciation, serious intestinal disorders and even death.

The new compound has an advantage over present treatment methods because it is injected into the dogs rather than fed to them and it requires no special preparation of the animal before treatment. Animals fed with medicines often subject handlers to bites and also require that the worm-ridden animals be purged or kept from food for a certain period to make the medicine effective.

The drug is reported to be effective against three major species of canine hookworms and has no toxic side-effects on dogs.

BLOOD GETS HOTTEST IN BRAIN AND LIVER

The next person who calls someone hot-headed may have science on his side. A University of Wisconsin medical researcher has found that the hottest blood in a human body comes from the brain and liver. The measurements were made with a tiny temperature-sensitive instrument.

The study also overthrew a common assumption that blood is cooled as it passes through the lungs. Although blood vessels in the lung bring blood close to the exterior air, its temperature does not change.

In reporting that blood is hottest when leaving the brain and liver, the Wisconsin researcher explained that these organs have high metabolic activitity. This means they are busily engaged in the life processes which pertain directly or indirectly to the breaking down of food to obtain energy and to the constant replacing of worn-out cells. In other words, these organs get hot from hard work just as a person or machine does.

MAN'S BRAIN HAS STOPPED GROWING IN SIZE, SAYS SCIENTIST

Man's brain appears not to have increased in size since Neanderthal times about 100,000 years ago, says Professor Ernst Mayr, Harvard University evolutionist, in a monumental report, 'Animal Species and Evolution'

A three-to-four fold increase in the size of main's brain was the most important development during the two million year of man's evolution from man-like apes, says Prof. Mayr. That development underlies man's most uniquely human qualities: the widespread invention of tools, speech and writing, abstract thinking, social organization and the creation and transmission of culture.

Professor Mayr theorizes that what favoured the growth in brain size was the need for articulate communication, or speech, and the fact that survival depended increasingly on how well parents cared for the young.

By courtesy: The United States Information Service.

NOBEL PRIZE FOR MEDICINE—1963.

The 1963 Nobel Prize for medicine was awarded to three scientists. The £ 18,280 prize was presented to two British professors, Alan Lloyd Hodgkin and Andrew Fielding Huxley, and to Sir John Carew of Australia, by King Gustav Adolf of Sweden in Stockholm on December 10.

The three men share the medicine prize for their descoveries 'concerning the ionic mechanisms involved in excitation and inhibition in the peripheral and central portions of the nerve cell membrane', described by the Caroline Institute of Stockholm as a problem which has haunted physiology for 100 years.

Prof. Hodgkin, 49, is Royal Society research professor in physiology at Cambridge, where he is a Fellow of Trinity College. He is also a Fellow of the Royal Society, a member of the British Medical Research Council, and a Royal Society medallist.

Prof. Huxley, who will be 46 next month, is Jodrell Professor of Physiology at University College, London. Like Prof. Hodgkin, he is a Fellow of the Royal Society, and a former Fellow (1941-60) of Trinity College, Cambridge. He has lectured on neuro-physiology in Russia.

According to the Caroline Institute, Sir John Eccles has carried out work which interlocked with that of Professors Hodgkin and Huxley in that it made important contributions to the problems of ion transfer across the cell membrane.

A spokesman of the British Medical Research Council said: 'Prof. Hodgkin and Prof. Huxley have been carrying out extensive investigations of the functions of the nervous system.

'They have been trying to supply more knowledge about how nerve cells work. The more we know about this subject, the better position we will be in for treating diseases and disturbances connected with the nervous system.'

Last year, the Nobel medicine prize was shared by Dr. Francis Crick and Dr. Maurice Wilkins, both of Britain, and Dr. James Watson, of the United States, for their work on heredity.

By courtesy: British Information Services, New Delhi.

New Trends in Science Education

Summer Institutes Programmes

Programme for 1964

Following the success of the Summer Institutes of 1963, the National Council of Educational Research, and Training, the University Grants Commission and the United States Agency for International Development propose to hold jointly 16 Summer Institutes in 1964, four in each of the subjects, viz., Physics, Chemistry, Biology and Mathematics. The increased number of Institutes will afford opportunities for a larger number of teachers getting trained in the new methods, thus paving the way for still larger numbers in the year to follow. The venues and dates for these Institutes will be decided shortly.

Programme in Ahmedabad

Shri C.R. Pathak, Principal, Swastik High School, Ahmedabad, has been active in promoting the new programmes in science education in Ahmedabad. He arranged and coordinated a meeting of the Headmasters Association of Ahmedabad and of the Science Consultants from Gujarat State in Ahmedabad during the period September 8 to 12. During this time, several presentations were made regarding the new programmes to these groups and also to university groups, new programmes were described and many of the new films shown in connection with these meetings to university faculty and students. At the same time, there was a meeting of the Science Club Sponsors from four states in Ahmedabad, conducted by the Department or Science Education of the NIE and these programmes were also presented at that meeting. Both Dr. and Mrs. N. E. Bingham were guests at these seminars.

Under the direction of a committee consisting of Dr. Vikram A. Sarabhai, Physicist and Director of the Physical Science Laboratory, Dr. K.B. Shah, Physicist, Physical Science Laboratory, and Shri C.R. Pathak, Principal of Swastik High School, an organization called the Improvement of Science Education Group has been formed. This group holds meetings for teachers every fortnight in which portions of the new programmes for teaching science are presented. Miss Vasu R. Parekh and Shri N. Sutaria, both of whom were in the Biology Institute in Madras last summer, also participated in these meetings.

In addition, this Improvement of Science Education Group holds Saturday morning meetings for highly selected secondary school students in which they are doing experiments of and studying the new PSSC Physics programme.

Dr. Vikram A. Sarabhai, further writes, 'We have now reached a stage when this PSSC material can be used in a systematic manner by teachers and students. You will be glad to learn that at the last meeting of the Board of Studies of Physics of the Gujarat University, the adoption of this approach and the use of the material was formally approved.'

He also wishes that steps should be taken to explore production of the PSSC films here in India with the idea that if this could be done, then these films would be available for use in Gujarat University and other Universities which may follow the lead of Gujarat University in this respect.

Under the leadership of Dr. P.C. Vaidya, Professor of Mathematics at Gujarat University, a group of teachers has been organized to study the new Mathematics programme. Shri G.A. Dalal, who was a member of the Mathematics Institute, is associated with these meetings.

Science Masters Association Scheme, Andhra Pradesh.

Shri V.V. Ratnam, Associate President, State Teachers Union, Government Multipurpose High School, Mahboobnagar (Andhra Pradesh) has submitted a copy of a Science Masters Association Scheme, which he is organizing in Andhra Pradesh as part of the State Teachers Union. In this proposal for the organisation of the Science Masters Association, he gives a clear picture of the Physical Science Study Committee course in Physics.

His prospectus for the new Science Masters Association is organized under the following headings: (1) The Scientific Revolution; (2) The Teaching of Science; (3) The Objectives of Teaching Science; (4) Problems before us; (5) Plans of the Government; (6) Physical Science Study Committee and its Physics Course; (7) The new programmes in Physics, Chemistry, Biology and Mathematics developed in the United States; (8) American Scheme in India; (9) Science Masters Association, State Teachers Union, Andhra Pradesh:

(a) Aims
(b) Procedures to be adopted
(c) Memberships
(d) Eligibility of Membership
(e) Its Functions
(f) Constitution, Samiti or Sector
(g) Parishad
(h) State
(i) Functions of Samiti, Parishad and Centre
(j) Distribution of Finances

In this way, Shri Ratnam is developing interest in the new programmes in science throughout Andhra Pradesh.

CHEM Study

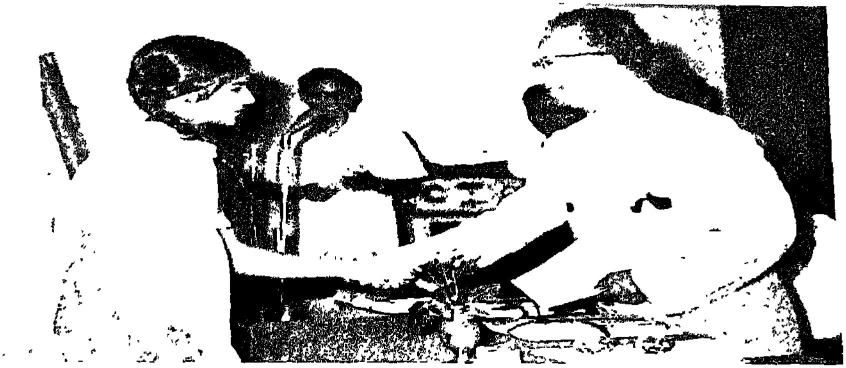
Shri K. Venkataramiah, Science Teacher at Sri Siddaganga High School, Tumkur, Mysore State writes:

'I have succeeded in introducing the first six chapters of CHEM Study to my students. I have also integrated the chapters on rates of reactions, equilibrium of reactions with the normal contents of the syllabus in chemistry that I have to do.

'More than that, I have been effectively using the experimental approach to science teaching. I have realised the wonderful value of making students understand the processes of science through their own active participation in conducting experiments, devising improvised apparatus, drawing charts, making models and such other science activities.

'I have been seeking the cooperation of my science colleagues in bringing about the revolution in science teaching at least in my school. I am happy to tell you that science learning and teaching have become very delightful in my school'.

Shri K. Venkataramiah was a participant in the Summer Institute in Chemistry at Poona, held in 1963.



Prof. Humayun Kabir, Union Minister for Education, congratulating Kumari Geeta Trivedi, one of the awardees of the Science Talent Search

Dr. D. S. Kothari presenting a set of books to Kumari Prabha Bapat, another awardee of the Science Talent Search

The awardees and the resource persons at the National Physical Laboratory, New Delhi

News and notes

WORKSHOPS OF SCIENCE CLUB SPONSORS

TWO Zonal Workshops of Science Club Sponsors were held, one at Government Constructive Training College, Lucknow from August 20 to 29, 1963, and the second at A.G. Teachers College, Ahmedabad from September 3 to 12, 1963. The participants prepared a number of models and projects and wrote the blueprints of several others which will serve as samples for other science clubs after their publication.

The programme for the next six-month period (October 1963 to March 1964) includes the following workshops :

State-level workshops to evaluate General Science textbooks of Punjab	2
All-India Workshop to develop a General Science curriculum for Higher Secondary Schools ..	2
All-India Workshop for developing the syllabus for the Summer Schools for Secondary Science Teachers	1
All-India Workshop of authors of General Science textbooks for Classes I-VIII	2
Zonal Workshop for Science Club Sponsors.	1

WORKSHOP FOR TALENTED STUDENTS

A workshop for talented students (selected under the Science Talent Search Scheme) and the science students in the merit list of the Central Board of Examination, New Delhi was held at the Tutorial Library Buildings, Delhi University from October 3 to 12, 1963. In this Workshop, professors from different universities were invited to chalk out a detailed programme of the Workshop and also to produce an accelerated programme of education for the talented students.

The programme of activities of the Workshop included lectures on scientific topics; trips to places of scientific interest and filmshows on scientific topics. One of the special features was the Workshop-Practice at the Hobby Centre, University of Delhi. Group discussions were held on all the days of Workshop. The Workshop was inaugurated by Prof. Humayun Kabir, Minister for Education, Government of India and the Valedictory function was presided over by Dr. D S. Kothari, Chairman, University Grants Commission, New Delhi. Books, certificates of merit and badges were distributed to the meritorious students on the closing day of the Workshop. Books worth Rs. 1700/- were distributed to the seventeen awardees at Rs. 100/- per awardee.

The following publications were brought out on the Science Talent Search Scheme :

1. *Science Talent Search*
   A pilot project. (Factual Report)
2. *Scientists of Tomorrow*
   Biographical sketches of the awardees.

3. *Essays in Science*

Collection of essays written by the participants in their Essay Test.

A detailed scheme has been worked out for the implementation of the scheme all over the country and necessary steps have been taken towards the same. It is envisaged to have the examination centres for the Science Talent Search at each district headquarters of each State in the country.

The application forms will be available from the District Inspector of Schools, or the District Educational Officers or a parallel authority.

Those students who are in the final year of a Higher Secondary Multipurpose Schools, P.U.C., Senior Cambridge and first year of Intermediate (XII year course) will be eligible to appear in the examination provided they have obtained at least 55 per cent marks in science subjects at the annual examination of the preceeding class.

The examination for 1964 will be held on a Sunday in the month of February 1964 and there will be two written papers, one of science aptitude test, and the other an essay paper. A project report will be written by each contestant and on the basis of the theory marks obtained by the contestants, they will be interviewed at suitable centres in India The top 350 candidates will be selected for the award of scholarships and/or certificates of merit. The chief conditions will be: (1) the student must have joined a course in basic sciences for three years leading towards a B Sc. degree, and (2) should not avail of any other scholarship. The next 200 in the order of merit will be considered for the award of only certificates of merit.

A detailed brochure has been prepared which will give sufficient information regarding 1964 Science Talent Search.

EXHIBITION OF SCIENCE BOOKS

An exhibition of science books received from the Asia Foundation was organized at Ahmedabad from September 8-12, 1963, along with the Zonal Workshop of Science Club Sponsors at the A.G. Teachers College. Shri J.P. Naik of the Ministry of Education inaugurated the exhibition, and a large number of students and teachers from the town and the neighbouring places visited the same.

TEXTBOOK PANELS

Physics Textbook Panel

The fourth meeting of the Panel was held from August 12 to 17, and the fifth meeting from October 23-29, 1963. Nearly 36 chapters out of 52 have been written and these were discussed. The rest of the chapters are expected to be written by the end of December 1963, and the entire draft of the text matter will be finally discussed at the meeting to be held in January 1964.

A pre-publication booklet, on the textbook to be published has been prepared.

Chemistry Textbook Panel

The Chemistry Text-book Panel met on August 3 and 4, 1963 and again from October 21 to 26, 1963. For the last meeting of the Panel, four experienced secondary school teachers were associated as special invitees to give the Panel members an idea of the reaction of practising teachers in the field to the work that is in progress.

The syllabus on which the textbook is being written has been finalized after thorough discussion of the details. A few sample chapters were read in the last meeting by various author members of the Panel and the manuscript was discussed in detail with a view to improve the present draft and also to form a basis for the writing of future chapters. It was also decided to complete the first drafts of all the chapters by December, 1963.

Biology Textbook Panel

As already reported the matter for all the 63 chapters have been written and most of these have been finalised. The remaining few are being finalised. The local members of the Panel are working on their chapters whenever they can spare the time. Two members from Banaras were in Delhi from October 23 to November 3, 1963 and worked on the chapters allotted to them. The chapters that have been finalised are being edited.

The manuscript of the pre-publication booklet is ready for the press. This booklet explains the need and scope of a comprehensive textbook suitable for the Higher Secondary Schools of the country. It also includes a chapter from the book. Another chapter for advance publication is ready and when published will be circulated among biology teachers to elicit their opinion.

A meeting of the Panel was held on November 3, 1963 when details of the publication of the pre-publication booklet were discussed. The members expressed their opinion about the format, layout, the paper to be used and the illustrations to be used. Their decisions have been conveyed to the Council.

Books
For your science library

Physics: Foundations and Frontiers. Gamow, George and Cleveland, John M. Prentice-Hall of India (Private) Limited, New Delhi. 1963. Rs. 6.00: pp XVIII+551.
This is a reprint of the book published by Prentice-Hall International, Inc. Englewood Cliffs, N.J., in 1961.

The main object of the authors in writing the present text is to explain the foundations of classical physics as developed by Galileo, Newton, Faraday and others and at the same time to make the student acquainted with the newer developments beginning with the discovery of X-rays, radioactivity and the electron, and the formulation of the quantum theory and the theory of relativity.

Calculus has not been used in the book and, therefore, the equation for uniformly accelerated linear motion $d=v_0t+\frac{1}{2}at^2$ (p. 39) or the equation for uniformly accelerated angular motion $\theta=\omega_0t+\frac{1}{2}\alpha t^2$ have been derived from the simple consideration of average velocity. But at the same the book discusses not only the special theory of relativity but also the general theory of relativity and many topics in modern physics like the uncertainty principle, the antiproton, the antineutron, the neutrino, the bubble chamber pi and mu mesons and other elementary particles and many other topics.

The book includes a large number of interesting and thought provoking illustrations some of which in the chapter on the special theory of relativity have been based on those in Gamow's popular book *Mr. Tompkins in Wonderland.*

The authors have been able to include a large number of applications of classical physical principles in everyday life as well as many modern applications like the electron microscope, radar, electronic computers, the determination of age by radioactive methods, etc.

The authors have not defined the fundamental units in a systematic way. The second is defined by the statement (p.6), 'A day is divided into 24 hours, and each hour is subdivided into 60 minutes, with each minute further divided into 60 seconds'. No attempt has been made to link the second with the mean solar day or the year 1900. Similarly the metre has not been equated with the number of wave lengths of krypton and the ampere has been defined as, 'one ampere is a current of one coulomb per second'.

It is surprising that the same figures (2.14) and (115.5) appear again as figures (5.7) and (19.5) respectively. Also advantage of reprint has not been taken to make the list of elements on page 355 up to date.

The book has been written in a very interesting style. It should be useful not only to students but also to the teachers in clarifying many of the physical conceptions.

Ordinary Level Physics. ABOTT A.F. Heinemam, London: Allied Publishers-Bombay: 1963. pp. xxiv+665.

The book is intended to be used as a textbook by the students studying up to the Ordinary Level of the General Certificate of Education. In addition to the usual topics included in older books, it gives a fair account of the atomic concept of matter. It also includes a large number of line diagrams and halftone illustrations. The halftone illustrations include many useful topics such as the graphite core of the nuclear reactor at Berkeley, the Zeta at Harwell, the proton synchrotron at CERN, the Atlas Rocket, the refrigration hold of a cargo vessel and the current balance at the National Physical Laboratory.

It gives a good description of many of the applications, of the Physical principles in every day life. This has necessitated the omission of some topics which are usually found in Indian books meant for this class of students. For instance, it does not describe the ice calorimeter, the steam calorimeter, steam engine, the internal combustion engine, and the reflecting telescope. But this has been compensated for by many modern applications such as the jet engine, gas cooled nuclear reactor, magnetic separator, motor car coil ignition system, and the Van de Graff particle accelerator, etc.

The book takes the MKS system of units as the basic units and gives the modern definition of the metic and the ampere. But the second is still defined as 1/86,400 fraction of a mean solar day. Also the book does use the concept of vectors although vector and scalar quantities have been defined. In dealing with numerical examples on mirrors and lenses both the sign comentions (the new cartesian connection and the real is positive connection) recommended by the physical society have been given without discussing their relative merits. It would have been more desirable to have given only one sign comention.

At the end of each chapter a large number of questions have been given which enhances the value of the book.

R N. RAI

An Approach to Natural Science. BREHAUT D.H. *et al.* Methuen & Co. Ltd., London W.C. 2: 1960. pp. 264.

Science can no longer be taught as a mere collection of established facts to be remembered and reproduced at the examinations. School science should be shown to be a living body of knowledge. It should be presented in such a manner that the pupil is led easily from the particular to the general truth and encouraged to apply what he has learned by making further investigations. Pupils have to be helped to understand something of what scientists do and why they do it. Their interest in science should be stimulated for its own sake. These are some of the modern views of teaching science and these are kept as ideals by the authors (five in number) of this book.

The chapters in this book include all topics usually found in an introductory course in biology, chemistry and physics Details and references are given to enable teachers to deal with those aspects which may not be their speciality. Emphasis is laid on developing a correct approach to science through individual work of all kinds both in the laboratory and in the library.

The matter in Chapters 1-6 is suggested for the first year course. After Introduction in Chapter I, the others deal with, Our Solar System, Air, Water, Making Measurements, and Heat. In every chapter there is an attempt to present a continuous course rather than one with biology, chemistry and physics separately.

Chapter 7 to 13 are recommended for the second year course. Chapter 7 is on Food, and deals with the structure and function of plant parts, photosynthesis, properties of light, hardness of water, CO_2 cycle and abnormal nutrition of plants. It will be seen how topics of different disciplines are introduced in an integrated manner. The other chapters deal with, Salts, acids and bases, Soil; Changes of State; Nutrition; Life histories (of butter-cup, cabbage-white butterfly, and the frog); and coordination in animals (sense organs and nervous system). Chapters 14-15 are meant as introduction to the third year specialist course in physics and chemistry. While Chapter 14 is on Electricity, Chapter 15 is concerning the Nature of Matter. This chapter includes information on living and non-living chemicals.

Each chapter has a summary, and a list of books to read. Other useful information is given in several appendices. There is a very useful bibliography at the end, chapter by chapter as well as general references. This book will be useful to both the teacher and the student.

The Garden in the Plains. HARBER AGNES W. 4th ed. Oxfrord University Press, London: pp. xvi+480.

This book on gardening is intended for the beginners who will find the matter very useful in laying out a small garden in their homes or at the school. The book is not elementary nor is it very advanced. The book is in six parts. Part I is the Garden in general; Part II Gardening Operations; Part III Trees, shrubs and permanent garden features, Part IV Flowers; Part V Vegetables and fruits; Part VI Miscellaneous.

The first two parts contain a good deal of information on laying out a garden, management of the soil, manures, fertilizers, methods of propagation and about pests and diseases. The next three parts deal with plants that are commonly grown in any garden. These include trees, shrubs, other features like hedges, rockeries, grasses and lawn, annuals, flowering plants, and vegetables and fruits. The different varieties are described and special instructions are given under some groups like, roses, chrysanthemums, etc.

This book will be very useful to the students and the teacher who wish to start a school garden or a kitchen garden as one of their club activities; particularly the part dealing with vegetables and fruits. The last part under the title Miscellaneous has useful information on some recipes and suggestions for flower arrangement. There is also a section on garden implements and a garden calendar.

Micro-organisms as Allies. The Industrial use of Fungi and Bacteria. DUDDINGTON C.L. Faber and Faber, London · 1961. pp. 256, 25s.

Fermentation is an old process which man has used since the dawn of history to make wine and bread. The discovery of penicillin and other antibiotics has resulted in the rapid developments in the field of industrial microbiology. This is an important branch of industry which, in its various phases, is now affecting our lives at every turn.

Micro-organisms as Allies provides a general account, for the layman as well as to a student of biology, of the modern developments in this exciting field.

Chapter I describes various microorganisms which are used by man in preparing many useful products. For the brewing of beer and the making of wine and bread, yeast is used and this is described in the next four chapters The versatility of yeast, besides its utility in the making of bread, beer and wine is described in the last of these four chapters. From the yeasts we get industrial alcohol, vitamins, fodder for animals and at a pinch food for man. In the next two chapters the moulds in antibiotics and industry are described.

The story of penicillin is very well described giving a wealth of details of its mass manufacture. The remaining chapters describe useful bacteria as our smallest allies, the factory-living bacteria and other bacteria used for man's good. How bacteria are used in making cheese and other dairy products, sauerkraut, pickles, silage, flax retting are some of those described. Among the nitrogen fixers are bacteria and the blue-green algae of the rice fields. The last chapter looks forward to many more uses of these little organisms to make man's life more comfortable. Some of these are the use of gibberellic acid in agriculture and horticulture, and the production of methane from dung and the use of this as a source of power for lighting and other uses on the farm. Some of the other dreams of the industrial microbiologist are the production of sulphuric acid from waste sulphide residues through the agency of sulphur bacteria and the possibility of obtaining heavy hydrogen with the aid of bacteria.

S. DORAISWAMI

Guidelines for Development of Programmes in Science Instruction. National Academy of Sciences and National Research Council. U.S.A. Washington D.C. 1963. Publication No. 1093. pp. viii+68

This pamphlet deals with the report of a study conducted by the National Academy of Science in collaboration with the National Research Council, Washington, in seven countries of south and south-east Asia and deals primarily with the teaching function of the laboratory in secondary school science programmes. The main recommendation of the report is to have science courses based on experiments and to have textbooks dependent upon and integrated with laboratory experiments. As this recommendation is diametrically opposite to what is believed and followed in the secondary schools and colleges in India, the pamphlet should interest every science teacher and educator in this country.

The pamphlet deals with science education and the role of the laboratory, its rationale, purpose and implications, and makes useful suggestions regarding the content and structure of laboratory work, apparatus and materials, buildings and services and lastly the preparation of the science teacher.

V.N. WANCHOO

Teaching Science in Today's Secondary Schools. THURBER AND COLLETT. Allyn and Bacon, 1961.

This is an excellent and up-to-date text on methods of teaching science. It introduces the inexperienced teacher to the basic principles of learning in Chapter 2 and 3. The special techniques of teaching science is very well developed in Part II of the book (Chapters 5 to 11) through laboratory exercises, demonstrations, excursions, field trips, audio-visual materials and tests. Later on, emphasis has been laid on the activity approach to lesson planning and how to organize materials for unit planning for general and special purposes.

Chapters (11 and 16) dealing with types of objective tests, construction of such tests, setting and maintaining standards and grading will be useful to the prospective teacher in view of the increasing emphasis that is now being laid on objective assessment and evaluation in our secondary schools.

The objectives of science teaching, its correlation with the goals of general education have been clearly dealt in Chapters 1 and 12. A significant feature is the emphasis given on close co-ordination with mathematics and languages in the science programme (Chapters 18 to 20).

The guidance given in organizing co-curricular activities through Science Projects, Science Clubs and Science Fairs in schools (Chapter 21 to 23) will prove very helpful and informative to the experienced teacher.

Constructive suggestions for setting up and equipping the laboratory as well as for improving the existing situations are useful both for the new and the experienced teachers.

N. K. SANYAL

Chemistry Creates A New World. JAFFEE BERNARD, Revised edition. Pyramid Books, Pyramid Publications, Inc., New York: 1957, 75 c. pp. 256 (paper back edition).

This book gives an interesting account of the multiplicity of chemical marvels in the fields of agriculture, medicine and public health, industry, transportation and warfare. Written in simple language the topics under discussion are brought within the comprehension of the layman. The development of the many 'wonder drugs' synthetic fibres like nylon and dacron, synthetic petrol, the new metals, in short the spectacular progress of chemistry in the service of man has been described delightfully well in about 200 pages. 'The cultured man of today can no more ignore science than the cultured man of the Middle Ages could ignore the Christian Church or the feudal system', says Seaborg in his introduction. And it is books of this nature which bring knowledge to people in an assimilable form.

Penguin Science Survey—1963

A. GARRATT AUTHUR (ed.) Penguin Books Ltd., Middlesex, 1963, sh. 7'6. pp. 224, 16 pl.

B. BARNETT S.A. and MCLAREN ANNE, (ed.) Penguin Books Ltd., Middlesex 1963. sh. 7'6. pp. 242, 9pl. 42 figs.

Part A contains articles on astronomy, cosmology, space research physics, chemistry, mathematics and education. The aim of this book is to acquaint the lay reader as well as the professional scientist who wishes to keep abreast of developments in fields other than his own. Such an effort is indeed laudable because it helps the readers to extend their visions to the expanding frontiers of science.

The speed with which science is being translated into technological achievement is something remarkable. This is true in chemistry as evidenced by the articles on synthetic fibres and the plastics and others. Of particular interest is the article on 'Science Teaching in 1962' by Boulind, the Chairman of the Science and Education Committee of the Science Masters' Association.

Part B contains articles on biology, genetics, agriculture, medicine and zoology. This book makes available some of the biological facts and ideas which people need today. Under Matters of Life and Death are presented features on Radiation, Chromosomes and Diseases in Man, World Health, contraception in its modern context, and Family Planning in East Asia. Following this are a few on culture of animal cells, cell surgery and New Light on Tissue Transplantation. The last chapter is by J.B.S. Haldane on Life and Mind as Physical Realities.

I.C. MENON

Microbes at Work. SELSAM MILLICENT E. William Morrow & Company, New York: 1953. pp. 95.

Microbes, the tiny living things are found everywhere and are intimately associated with man's life, affecting it in many ways. The common man is quite familiar in his day-to-day life with the results of the activity of microbes without himself knowing how they are caused. In this fascinating little book the multifarious common activities of the microbes, with reference to our food stuffs in particular, are dealt with in a very popular way.

In the first chapter, we are introduced to the three types of microbes, viz., bacteria, moulds and yeasts, their structure, mode of life, culture methods, etc.

In the second chapter the role of microbes in spoiling our food stuffs, the various factors that encourage these undesirable microbes to grow and the application of these findings in refrigeration, canning, salting and drying to keep down their flora in food stuffs are discussed.

The third chapter deals with the beneficial microbes that are responsible for the conversion of certain food stuffs to more tasty ones like curd to cheese, dough to bread, fruit juice to vinegar, cucumber to pickle, etc.

The last chapter is devoted to the soil microbes that are responsible for making our soil fertile, helping our farm animals grow big, faster and above all for providing us the wonder drugs like penicillin and streptomycin to fight against diseases.

This book is enriched by plenty of illustrations. The style is direct and the language easy and simple. This is a well written useful look that can be recommended for supplementary reading in science to broaden the interests of science among school children.

G. RAJU

SELECT BIBLIOGRAPHY OF SOME SCIENCE BOOKS

1. **A Garden Handbook for South India.** PLATT A.J. & RAMA RAO B.A. Macmillan & Co. Madras: 1956, pp. 118. Rs. 2/25.

The book gives suggestions for successful gardening based on practical experience. Includes cultivation of flowers, vegetables, trees and rock gardens. There is a useful gardening calendar. It is suitable for secondary students, and for club activities, if gardening is a hobby.

2–5. **Exploring Nature Series.** HYDE G.E. and ARNOLD E.J. Leeds. 1962 pp. 24 Rs. 2/40. each.

The whole series gives very well illustrated accounts of the following:

Book I Butterflies
,, II Wild fruits
,, III Woodland flowers
,, IV Insects in the garden.

The handicaps of these books are that almost all specimens are of British origin and the price is prohibitive for Indian conditions. They are however excellent models of presentation for children, for authors of similar books for young children with Indian specimens.

6. **The Air Around Us.** JOSLIN I.S., Macmillan & Co. London: 1962 pp. 172, 7s. 6d.

Properties and composition of air are discussed with suitable well illustrated experiments. Suggestions for activities are suitable for middle grades.

7. **Water in the World.** JOSLIN I.S., Macmillan & Co. London: 1962. pp. 167, 7s. 6d.

Sources, properties, composition and uses of water are discussed. Good description of principles of floatation, and water supply are given with simple illustrations. Suggested activities are suitable for middle grades.

8. **Science Puzzlers.** GARDNER MARTIN, Macmillan & Co. London 1963. 10s. 6d.

A selection of experiments on various branches of physics which are instructive as well as entertaining. It is a very practical book which will interest the middle grades.

9. **Science Shapes Tomorrow.** LEACH GERALD, Phoenix House, London: 1962. pp. 140.

It is a very good source book of modern developments in science. The topics include atoms, atomic energy, radio astronomy, computing machines and modern aspects of biology like DNA and modern processes of food cultivation. It contains some good photographs and simple diagrams. It is suitable for secondary level.

10. **The Boy Scientist.** JOHN LE WELLEN, Phoenix House, London: pp. 268, 185.

A historical development of physics from Galileo to Einstein. Some difficult concepts of physics like graviation, laws of motion, Bernoulli's principle, nature of light, sound, electricity and relativity are dealt in a simple way with over 150 explanatory diagrams. The continuous and revolutionary developments will spur a boy to seek further knowledge. The last chapter emphasizes that science continues the search for an answer on a thousand fronts.

It is suitable for the Higher Secondary level and libraries.

11. **A History of Invention.** LARSEN, EGON, Phonex House London, 1961. pp. 382, 215.

The book deals with the history of science. The entire sphere of technical history is divided in to three main sectors—Energy, Transport and Communications. The important trends are followed with biographical lights on many major inventions.

Part I deals with wind, water, electricity, solar and atomic energy.

Part II deals with various types of transport, road, railways, ships and aeroplanes.

Part III deals with communications, printing, telegraphs, telephone, radio, teleprinting, television and everyday electronics.

The book is comprehensive, informative and also entertaining. It can serve as a reference book for schools. There are 68 photographs and over a hundred diagrams which are historical and explanatory. Suitable for higher students of secondary and junior college level.

12. **Every House a Home.** COCKER, KATHLEEN M. J.M. Dent London 1963 pp 88, 6s.

It is a book on house craft and home economics. Suitable for social studies of secondary schools also. The topics dealt are the house, the home, its construction, furniture and fittings, ways of heating and lighting, family at home, food and its nutrition, family in the framework of society, cost of living, national income, incometax, etc. The examples and illustrations are British and hence unsuitable for Indian conditions.

13. **Modern Marvels of Science.** KEANE SIR RICHARD (ed.) Phoenix House London: 1961. pp. 48, 10s. 6d.

This well-illustrated book brings before the students, laymen and the scientist—who having specialised in his branch wants to keep abreast with a broad picture of what is being done in other spheres—an idea of the latest technological advances in science. An up-to-date account of remarkable machines which test, check and demostrate the ideas, researches and discoveries of the scientists is given in a popular way. The range includes chromatography, electronic computers, electron microscope, ultra-violet and infrared spectro-photometers, X-ray crystallography, radio-active thickness gauge, zone refining, klischograph, polychromator, radar and radomes, piston and turbine engines, blast furnaces and rockets.

The essays have attempted to bring the highly technical refinements of modern scientific development to the popular reader. The colour plates illustrating the machines are attractive and neatly labelled. It is a good reference book for library.

14—18. **How It Is Done Series.** FERGUSON C. C. Macmillian & Co., London, 1958, 1s. 4d. pp. 16 each

(1) How to Look after your Bicycle
(2) How to use your sewing Machine

(3) How your camera works
(4) How clocks and watches work
(5) How oil lamps and cookers work.

This series describes the working of some common everyday articles and machines. The broad principle involved and the working are described in simple language. The diagrams are simple and self explanatory. The books give useful hints for handling and precautions for using the machines and also practical tips for locating troubles. It is interesting for the middle grades.

19. **My Book of the Universe (Topic Books).** BROWN, JOHN G. Macmillian & Co., London: 1963. pp. 64, 55.

The story of the mysteries of the universe is given in a simple narrative style. An imaginary trip to space narrates space travel and a general idea of the universe. There are useful instructions on making a simple astronomical telescope. Guidance is given with the help of star maps to locate different stars and constellations in dififferent seasons. At the end of each of the four chapters is given 'Things to do yourself,' which will enable the children to pursue activities. Suitably illustrated, this is good reading material for the middle grades.

N.K. SANYAL